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EXPLORATION OF MUMMY CAVES IN THE ALEUTIAN ISLANDS

PART I. PREVIOUS KNOWLEDGE OF SUCH CAVES. ORIGINAL EXPLORATIONS

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The subject of human "mummies" has always had a peculiar attraction. This mainly because it is odd to see bodies hundreds or even thousands of years dead, yet still whole and showing more or less of the original features of their owners. But also because the subject appeals to mysticism, and has the halo of dynastic Egypt, where artificial mummification originated, was eventually applied to the bodies of all the rulers, the mighty and the rich, and reached the highest developments.

The practice of mummification resulted in general from a belief in future life. In the Old World it apparently remained limited essentially to Egypt, though it reached to some extent the Canary Islands. In later times it was practiced in a measure, and quite independently probably, among the Papuans of the Torres Straits; and with outstanding personages may have been attempted, more or less, elsewhere. It had not become habitual, so far as known, in any part of Africa outside of Egypt, in Europe or in Asia. But it developed in two wide apart regions in America—in Peru with the neighboring territories, and among the Gulf populations of Alaska, more particularly in the Aleutian Islands.

How the practice started in these two American regions is not known. It may have originated there from the same causes as in Egypt, and in each area independently; it may have developed in Peru and been somehow transmitted to Alaska, though this seems far-fetched—as would be the supposition that it reached Peru from Alaska. It would be hard to connect it in either region with Egypt—yet such a connection may not have been wholly impossible. At this date, unless some new evidence should come from Siberia, these problems are probably incapable of solution.

Mummification in both Egypt and in America was of two kinds, the natural and the artificial. Natural mummification of bodies—which in all probability suggested eventually the assisted or artificial practices—took and now takes place in all regions and places where there is a lack of moisture. The deserts, dry caves, dry tombs, are its locations. Many natural mummies exist in the desert sands in Egypt, and many also were found in dry caves or rock-shelters in America, in parts of Peru, Mexico, the Southwest and

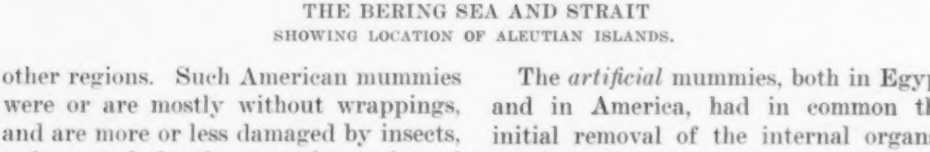
THE BERING SEA AND STRAIT
SHOWING LOCATION OF ALEUTIAN ISLANDS.

other regions. Such American mummies were or are mostly without wrappings, and are more or less damaged by insects, rodents and the elements; but a few of those found have shown remarkable preservation, so much so that fairly successful efforts were possible at a restoration, through certain fluids, of an approach to the original features of the heads, hands and feet of such mummies.[1] They were, and still are, as a rule, found in a sitting posture, with the arms and knees drawn up to the chest and the head bending forward.

[1] See: H. H. Wilder, *Am. Anthrop.*, 6: 1–17; also J. Gillman, *Am. Jour. Phys. Anthrop.*, 18: 363–69 and M. F. Ashley-Montagu, *Am. Jour. Phys. Anthrop.*, 30: 95–101.

The *artificial* mummies, both in Egypt and in America, had in common the initial removal of the internal organs; but the subsequent treatment of the body differed. The Egyptians embalmed the body by various balsams, pitch and other materials, and then artfully bandaged the body; the Americans used essentially air drying, and in some cases stuffing with dry moss or grass, after which, without pitch, balsams (so far as known) or bandages, they dressed the body in the best available clothes and made up the whole—with cotton in Peru, with mats and skins in the Far Northwest—into a bundle.

In this place we will deal only with



LOCATIONS OF BURIAL CAVES AND ROCK-SHELTERS,
ANDREIANOV ISLANDS, ALEUTIAN CHAIN.

UNALASKA, IN THE EARLIEST PART OF THE NINETEENTH CENTURY
(AFTER A DESIGN BY CHORIS, 1822).

artificial mummification in the Far Northwest and more especially with that in the Aleutian Islands.

That the practice of artificial mummification of the dead once existed in these islands was repeatedly reported by the Aleuts to the Russians.

The first account of it is found in Martin Sauer's report (Lond., 1802) of Commander Billings'[1] visit (around 1790) to the islands. Speaking of burials among the Aleuts of the Unalaska District, Sauer, who was the secretary of Billings and interpreter, says (p. 161):

> They pay respect to the memory of the dead; for they embalm the bodies of the men with dried moss and grass; bury them in their best attire, in a sitting posture, in a strong box, with their darts and implements; and decorate the tomb with various coloured mats, embroidery and paintings. With women, indeed, they use less ceremony. A mother will keep a dead child thus embalmed in their hut for some months, constantly wiping it dry; and they bury it when it begins to smell, or when they get reconciled to parting with it.

In Saryčev's account of the same expedition (Lond., 1806–7, II, 77) the same subject is briefly noted thus: "The entrails are taken out of the corpse; which is stuffed with hay."

A somewhat more circumstantial account of the practice is given, in 1840, by Bishop Veniaminov, in his classic and rare work on the Unalaskan Aleuts, among whom he spent ten years of his life[2] as their priest and friend. He says: (II, 80–81):

[2] I. Veniaminov "Zapiski ob ostrovach Unalaškinskago Otdiela." 3 vs. (in 2), 8°, Acad. Sc., St. Petersb'g., 1840.

LOCATIONS OF BURIAL CAVES AND ROCK-SHELTERS,
FOX ISLANDS, ALEUTIAN CHAIN.

A FINE, UNTOUCHED OLD SITE OF LITTLE KISKA

IN THE ALEUTIAN ISLANDS. THERE ARE LITERALLY HUNDREDS OF SUCH UNTOUCHED OLD SITES OF HUMAN HABITATION IN THE ISLANDS WHICH CAN BE READILY DISCERNED BY MEANS OF THEIR RICHER AND DIFFERENT VEGETATION.

In former times, in case of every Aleut who died, his relatives grieved over him for 40 days, and did not bring out his body from the house for 15 days. Several days after death they *embalmed* the body, *i.e.*, they opened it, and extracting all the internal organs, stuffed the trunk with dry grass and sewed it up. After that they dressed the body in his best and most favored garment, and swaddling it like a baby, they placed it in a framed skin "cradle" which they hung in the place where the individual died and where they kept it for another 15 days. . . . Bodies of the poorer and of the serfs they lay in caves. However, it appears that sometimes they lay in the caves also the rich, as may be witnessed even now according to some indications.

And further (III, 11):

From the body of a man who died at sea, in order that he should not decay rapidly, they nearly always removed the internal organs and buried them separately.

The natives told Veniaminov of two caves with "mummies," one on the Kagamil and one on the Tanginak, or Korabl (now Shiprock), islands. Kagamil, he says (I, 135–36):

is further remarkable for the fact that on its western side, in a cave, there may up to now [1835] be seen the dead bodies of some people hanging in swings. By them are found all their goods: mats, parkis, otter skins, weapons, kind of bags, etc.; and they say that the bodies as well as everything that is with them are perfectly well preserved, but that no one must touch them, because, they say, those who touched even the weapons became afflicted with open sores all over the body, and after long suffering died.

And (II, 132):

The Aleuts tell that some of the bodies to be found even now in caves on one of the Four-Mountain-Group Islands, were already in the earliest times of the Aleuts in the same condition as they are now. They lie one by the other, dressed in fur parki, their beard and hair brown or reddish, the skin on the body blackish. And it was from these bodies that the hunters endeavored to cut parts of the flesh and especially some part of the hand and of the small finger, or at least a part of the garments, [for good luck in hunting]. But he who had such things, even though really more fortunate in hunting, nearly always died early and with a horrible death—beginning to decay already in his best years.

As to the Korabl Island (Shiprock), Veniaminov says:

On the south side of this little island there is a cave in which there are the bodies of the old-time (unchristened) Aleuts, in sitting posture, and which even now are free from decay.

Going to such caves was forbidden to the young. According to the same author (II, 122, ftn.):

For a long time, even after the acceptance of Christianity, the old men and women prohibited the younger from going to forbidden places, but now there are none of such forbidden spots, with the exception of the caves where are found the bones of dead former Aleuts.

A. L. Pinart, a French archeologist, visited some of the eastern Aleutian Islands in 1871 and found there two burial caves, one on Unga and the other on Amoknak. He made a remarkable collection of carved and painted wooden

objects in the Unga cave,[3] but saw no whole mummies there. In the Amoknak cave there also were no whole bodies anymore, but there were remains of the same. Pinart called this cave to the attention of Dr. Dall and in 1872 and 1873 the latter explored it. In his article on "Alaskan Mummies"[4] Dall refers to these and other such caves as follows:

Among the localities which have been visited personally by the writer, are caves in Unga, one of the Shumagin Island, and others on the islands of Amaknak and Atka, further west. In all of these the remains of mummies existed: but the effect of falling rock from above, and great age, had in all the caves except that of Unga, destroyed the more perishable portions of the remains, and in the latter place only fragments remained. Many stories, however, came to hand in relation to a cave on the "Islands of the Four-Mountains" west of Unalashka, where a large number of perfectly preserved specimens were said to exist.

When in the vicinity, in 1873, we were unable to land and test the truth of this history, on account of bad weather and the absence of any harbors.

In 1874, however, Captain E. Hennig, of the Alaska Commercial Company:

being employed in removing some hunters from the island of the Four Mountains, was enabled, after seven unsuccessful attempts, to land at the base of the cliff, where the fallen rocks form a kind of cave, and was directed by the natives to the exact spot. Here he obtained twelve mummies, in good condition, besides several skulls of those which, being laid near the entrance of the cave, had become injured by the weather. There was also a moderate number of carvings and implements found, though some natives, less superstitious than the rest, had appropriated a quantity of weapons (reported to have once been there) for use in hunting. The island being volcanic and, in fact, still active, the soil is still warm, and the atmosphere of the cave was quite hot, which accounts for the extremely good preservation of the remains. Most of the bodies were simply eviscerated, stuffed with grass, dried, wrapped in furs and grass matting, and then secured in a waterproof covering of seal-hide. Two or three had much more pains bestowed upon them, and were of course of much more interest.[5]

To this in 1875[6] Dall adds:

Most of the mummies [from the Kagamil cave] were wrapped up in skins or matting as previously described, but a few were encased in frames covered with sealskin or fine matting, and still retaining the sinew grummets by which they were suspended. These cases were five-sided, the two lateral ends subtriangular; the back, bottom and sloping top, rectangular, like a buggy top turned upside down. With them were found some wooden dishes, a few small ivory carvings and toys, a number of other implements, but no weapons except a few lance or dart heads of stone. Two or three women's work bags with their accumulated scraps of embroidery, sinew, tools and raw materials were among the collection. . . . It contained thirteen complete mummies, from infants to adults, two of which were retained in California; and two detached skulls. None of the material showed

FIRST STAGES OF EXCAVATIONS IN AN OLD SITE ON AMOKNAK ISLAND

THIS SITE, WHICH IS STILL FAR FROM EXHAUSTED, HAS GIVEN US MANY HUNDREDS OF INTERESTING SPECIMENS, INCLUDING SOME BURIALS. IT BELONGED ORIGINALLY TO THE PRE-ALEUTS.

[3] "Catalogue des collection rapportée de l'Amérique Russe" par Alphonse Pinart, Exposées dans le Musée d'Historie Naturelle de Paris, 1872, Paris; also, "La caverne d'Aknañh île d'Ounga (archipel Shumagin, Alaska), Paris (E. Leroux), 1875.

[4] *Am. Naturalist*, 9: 436, 1875.

[5] "Notes on Some Aleut Mummies," *Proc. Calif. Acad. Sci.*, 5: 399–400, 1873.

[6] *Amer. Naturalist*, Aug., 1875; reprint in the Indian Miscellany, Albany, 1877, 344–351.

THE AUTHOR, WITH AN OFFICER OF THE S.S. *TALAPOOSA* (ORDWAY, 1936).

any signs of civilized influences, all was of indigenous production, either native to the islands, or derived from internative traffic or drift wood. The latter comprised a few pieces of pine resin and bark, birch bark and fragments of reindeer skin from Alaska peninsula.

Regarding the mummies of the children, Dr. Dall says:[7]

The case [of these] was sometimes cradle-shaped, especially when the body was that of an infant. On these occasions it was often of wood, ornamented as highly as their resources would allow, painted with red, blue or green native pigments, carved, adorned with pendants of carved wood and suspended by braided cords of whale sinew from two wooden hoops, like the arches used in the game of croquet. The innermost wrappings of infants was usually of the finest fur, and from the invariable condition of the contained remains it is probable that the bodies were encased without undergoing the process previously described. The practice of suspension was undoubtedly due to a desire to avoid the dampness induced by contact with the soil.

As to the finds themselves, Dall says:[8]

The mummies of real interest were few in number. The most conspicuous was that of the old chief. I am informed that this body was enveloped in furs, dressed in the usual native attire, and furnished with a sort of wooden armor, formerly worn by the Aleuts. The whole was placed in a sort of a basket, in a sitting posture, and carefully covered with water-proof skins, secured by lines made of sinew, either braided or made into what sailors call "square sennit." This line, together with a net made of sinew, in which another of the bodies was secured, were very finely made, and nearly as perfect and strong as when first placed there. The matting, made of prepared grass, was exceedingly fine, in most cases far superior in finish and delicacy to any now made in the islands. One of the smaller mummies, in a triangular-shaped bundle or basket, had a pattern of a Maltese cross worked into a stripe of another color; this was quite fresh, and the grass still retained its red and yellow tinge. The largest basket has a wooden arrangement fastened with bone buttons, forming a broad hoop, which served it for a base. Most of the more carefully preserved specimens had been once suspended in the air by handles or cords attached to their envelopes.

The other articles found in the cave were stone knives and other implements, and a few carv-

[7] *Am. Naturalist*, 9: 436.

[8] *Proc. Calif. Acad. Sci.*, 5: 399–400, 1873.

ings, one of which was supposed by the finder to be an idol, but this is probably an error. A child's boot of native make was found in the cave, with the fur perfectly preserved, and in it was a little ivory image of a sea-otter. A number of other bone and ivory toys or trinkets were also found.

The only other worker in Alaska who gave direct attention to the Aleutian mummies and burial caves was Dr. Jochelson. The results of his inquiries and observations are published in his excellent "Archeological Investigations in the Aleutian Islands" (4 to, Carnegie Inst., Wash., 1925). After a discussion of their behaviors with the dead, Dr. Jochelson says (p. 42):

The Aleut achieved the art of mummifying the bodies of their dead, which made possible their preservation and postponed the time for final disposal. It may be contended that mummification could not succeed in the cold and wet climate of the Aleutian Islands, but such is not the case. The Aleut used no drugs for embalming, but proceeded as follows: An incision was made in the perineum and the intestines removed through the pelvis, or an incision was made over the stomach for that purpose. The intestines were carefully cleaned, all fatty substances removed, and then stuffed with dry scented grasses. Then the corpse was arrayed in its best clothing, over which a kamleika (water-proof shirt made of the guts of sea mammals) was drawn. Then it was arranged in a squatting position with knees drawn up to the chin. Wrapped in closely plaited grass-mats and seal or sea-lion skins taken from the cover of the dead man's boat, the corpse was lashed into a compact bundle with thongs of sea-weed ropes. Then the whole package was again wrapped in a net made of sea-lion sinews.

To which Dr. Jochelson adds (pp. 44–49):

An old Aleut informed us that not all Aleuts were embalmed, this being the privilege of noted hunters, especially whale-hunters. Corpses of honored people and of the families of chiefs were also mummified (p. 44). Two types of caves were used as burial places: one with deep grotto-like passages with a large opening, the other in the form of small hollows in the rock. Mummified corpses of distinguished people were hung up chiefly in the bottom of the grotto-like caves, while in the small caves, which evidently were regarded as village cemeteries, all the less distinguished dead were placed (p. 45). Small cave cemeteries of the second type, sack-shaped hollows in the rock, were found on Atka and Amaknax. Two such caves were discovered on Atka, near the Atxalax village site. Evidently both caves had served as burial places for the inhabitants of the village (p. 46). In addition to the large grotto-like caves in which the Aleut suspended their mummified dead and the smaller caves which served as village cemeteries, the Aleuts used compartments in their underground dwellings or special lodges for the disposal of their dead. For the latter two methods the bodies were prepared as for cave burial (p. 49).

Further on (p. 123), Dr. Jochelson mentions a burial cave on each of the islands of Ilak, Samalga and Ulagan, but those he did not examine; and he failed in his effort to reach the cave on Kagamil.[9]

The practice of partial preservation or mummification of some of the dead was not limited to the Aleutian Islands. It extended also to the Peninsula (or parts of it), to the Kadiak Island, to the islands of the Prince William Sound and to those of southeastern Alaska and British Columbia. Regarding the Peninsula and Kadiak Island, Dall,[10] after earlier sources, tells us as follows:

The practice of preserving the bodies of the dead was in vogue among the inhabitants of the Aleutian Islands and the Kadiak archipelago at the time of their discovery, and probably had been the custom among them for centuries. The Kaniagmut Eskimo, inhabiting the peninsula of Aliaska, the Kadiak archipelago and the islands south of the peninsula, added, to the practice of mummifying the dead, the custom of preparing the remains in some cases in natural attitudes, dressing them in elaborately

[9] Regarding this cave both Dall and Jochelson give a native tradition of a burial there, shortly before the Russians came, of a local chief with his family; and Dall believed that their mummies were among those taken out by Captain Hennig, which is possible, though doubtful. See later account of the cave.

[10] *Am. Naturalist*, 9: 434 et seq.; repr. in The Indian Miscellany, Albany, 1877, 344 et seq. (1881). See also his "On The Remains of Later Prehistoric Man Obtained from Caves in the Catherina Archipelago, Alaska Territory, and Especially from the Caves of the Aleutian Islands," Smithsonian Contribution to Knowledge, Washington, 1878.

SMOKING BEACH IN FRONT OF WARM CAVE ON KAGAMIL ISLAND IN 1936

THE WHOLE ISLAND IS A VOLCANO AND IS EVIDENTLY STILL ALIVE IN ITS INTERIOR. THE SMOKE AMONG THE BOULDERS ON THE BEACH RISES FROM BOILING HOT LITTLE STREAMS THAT ISSUE FROM THE CLIFFS.

> ornamented clothing, sometimes with wooden armor, and carved masks. They were represented, women as serving or nursing children; hunters in the chase, seated in canoes and transfixing wooden effigies of the animals they were wont to pursue; old men beating the tambourine, their recognized employment at all native festivals. During the mystic dances, formerly practiced before a stuffed image, the dancers wore a wooden mask which had no eye-holes, but was so arranged that they could only see the ground at their feet. At a certain moment they thought that a spirit, whom it was death or disaster to look upon, descended into the idol. Hence the protection of the mask. A similar idea led them to protect the dead man, gone to the haunts of spirits, from the sight of the supernatural visitor. After their dances were over the temporary idol was destroyed. . . . In Kadiak still another custom was in vogue. Those natives who hunted the whale formed a peculiar caste by themselves. Although highly respected for their prowess and the important contributions they made to the food of the community, they were considered during the hunting season as unclean. The profession descended in families and the bodies of successful hunters were preserved with religious care by their successors. These mummies were hidden away in caves only known to the possessors. A certain luck was supposed to attend the possession of bodies of successful hunters. Hence one whaler, if he could, would steal the mummies belonging to another, and secrete them in his own cave, in order to obtain success in his profession.

As to Prince William Sound, information is meager, but there is still a definite remembrance among the old timers of the region of "mummy caves" on at least one of the islands of this group. Farther east, along the Alaska Gulf and northwest coasts, carved mortuary boxes with desiccated remains, in one case a whole child mummy (now in the Museum at Seattle) have been found in the forests on some of the islands, but there is no recorded tradition about the practice of preserving the dead in these regions.

Original Explorations

The writer's original exploration for mummies was limited to the Aleutian Islands, and was based on the old Russian as well as Dall's and Jochelson's information, supplemented with some valuable hints from the old natives and other sources. The search began towards the end of the 1936 season, and continued through those of 1937 and 1938. Thanks to the U. S. Coast Guard it became possible to find a series of these caves, with results that collectively proved not only of first importance to physical anthropology, but from the cultural side amounted to a veritable resurrection of perishable objects that could be found in no other manner.

The search for the caves proved both exciting and dangerous. It will be best to give the details in the form of the original notes, for nothing else could do the work such justice.

1936–July 28. The fine Coast Guard boat "Chelan," Captain L. V. Kielhorn, is taking us off from the island of Kiska, where we have been excavating for several weeks. Calm to-day, but very foggy —as most of the time here. Can not even see the Little Kiska where we worked part of the time in a fine old site, and had some rare experiences. The Captain promises to stop in the bay at Kagamil Island where we are to find and explore the mummy cave that both Dall and Jochelson tried in vain to reach, and that has recently for our benefit been located by the "Brown Bear" of the Biological Survey, which kindly came to Kiska to tell us about it, and brought a mummy with a couple of bags of bones from the cave as evidence. The information as to the locality of the cavern is still somewhat indefinite, for the "Brown Bear" could stay only a short time due to weather conditions; but there is said to be a good landmark some distance beyond the cave in the nature of a steam jet issuing from the mountain.

July 29. Up early, for we are approaching the Four-Mountain-Group. But everything is so foggy that we can not even see a trace of the islands, though there are some huge volcanoes. Moreover the waters about the group are not

EXCAVATIONS IN THE WARM CAVE OF KAGAMIL ISLAND IN 1936

SINCE IT WAS IMPOSSIBLE, DUE TO LACK OF SPACE, TO USE ANY TOOLS, IT WAS NECESSARY TO DIG BADGER-LIKE. FORTUNATELY THE DEPOSITS WERE NOT HARD, BUT THE SALTY DUST AND THE HEAT AT LOWER LEVELS WERE RATHER TRYING.

yet well charted, so that the Captain feels unable to approach closely. With a great disappointment we must eventually leave, without getting even a glimpse of our Island. . . .

July 31–Aug. 3. Excavating on Amoknak Island.

August 4, 8:00 A.M. A message from Captain Dempwolf to meet him this A.M. and also Captain Kielhorn of the "Chelan" at Unalaska. Conference on the "Chelan" at 10, barometer rising, arrange to go once more to Kagamil at 2 P.M. Hasten back, recall companions—all excited and eager. Have lunch, at 1:20 a boat for us, at 1:40 all on the "Chelan," at 2 off for Kagamil. Weather and sea fairly good, though a "swell." Stop at Kashega, little native village of a few straggling Aleut dwellings, to discharge a sick woman.

August 5, 4:00 A.M. Dense fog—terrible. 6:30 A.M. Fog lifts as if by enchantment, and there, not far on the horizon before us, is Kagamil. Carefully find anchorage, in a shallow cove, have breakfast, and at 8:30 off in a dory for the "mummy cave" reported by the "Brown Bear."

After about an hour find the jet of steam—about seven miles from the ship; and soon locate also the crevice of the cave. The jet issues from a barren cliff a few hundred yards to the left of the cave, and other steam cloudlets rise from bubbling hot springs among boulders above and in rocky beach.

Cave well above reach of storms and spray. Its orifice a cleft in the volcanic rocks. Approach difficult, but soon mastered. Inside, cave low, a huge fallen slab in middle—some skulls, debris of skeletons, deposit of white salt-like substance over all. Two fairly large recesses of the cleft filled with debris of mummies left by foxes—shreds of matting, bones,

parts of skeletons—all on or in white deposit. Also some old driftwood and hand-hewn planks, evidently remains of crude platforms on which mummies had rested. In one of the recesses the white salt (which also encrusts, somewhat stalactite-like, much of the ceiling)—forms already a solid covering of some of the remains, so hard in places it can not be broken with a pick.

Space within cave limited, in most of it one can not stand up, in none of it can use shovels; must work with hands like badgers, but luckily much of deposit proves not hard. But there is soon a great deal of dust; also the recesses are dark, and there are but a couple of small searchlights to help along. As the salt[11] deposit is penetrated into, there appears mummy after mummy, in different states of preservation—male, female and especially children. Small children in unique baskets, woven, plaited or skin. Some loose specimens of stone and bone; grass bags with objects—no time to see; a huge whale shoulder blade with two apertures for handling; and two entire kayaks, though frame work and shreds of skin covering left only. My four boys (students) as well as myself work strenuously, to the limit, to secure as much as possible, for at any moment it may get rough or foggy outside and we be called off. The inside is very dusty, and the dust irritates, but do not mind. Wonderful riches. An officer and a couple of men from boat helping effectively—more can not get in. From time to time one or

[11] On analysis, later found to be actually mainly common salt.

THE WARM MUMMY CAVE ON KAGAMIL ISLAND

AS FOUND ON FIRST ENTERING IT IN 1936. THE CAVE WAS SO FILLED WITH SALTY DEBRIS AND MUMMIES THAT IT WAS AT FIRST IMPOSSIBLE TO STAND UP IN IT. THE REMAINS ON THE TOP HAD BEEN DESPOILED BY STARVING FOXES, BUT THE MUMMIES LAY IN PLACES SEVERAL DEEP. THE WHOLE CAVE WAS DRY AND WARM, HEATED BY THE HOT LAVA SOMEWHERE UNDERNEATH.

another must get out a little to get a few breaths of clean air.

Near 1:00 a sandwich outside the hole—eight minutes—then work again to the limit till 4:00 P.M., then must cease, to enable men to get back to boat for supper. Most fortunately weather has kept fairly good and no fog closed in. Load everything into a large dory which takes it to the ship—have so much the boat has to make two trips—and leave finally near 5:00. Main things secured, but all not yet exhausted. Yet no possibility of staying any longer.

The cave was dry and warm. As we dug down, particularly in the recesses, the deposits and even the air became steadily warmer, until, on the right, as the arm reached for about two thirds of its length, the deposits became almost too warm to work in.

Secured in all over 50 mummies, though most children; and about 30 additional skulls, besides numerous miscellaneous bones. In addition, a great quantity of partly damaged, partly still good, remarkably made and decorated matting; and there were a mass of shreds of fur (sea-otter), feather garments, feathers, dried-up birds or bird wings, shreds of various ingeniously made cords, many pieces of worked wood from kayaks, or armor, etc., etc.

When we reach the "Chelan" find all excited. The sacks of mummies, etc., make a great pile on deck forward of bridge, where the whole, for safety, at the Captain's order, is covered and secured under canvas.

On way home I have spotted in the crags of the shore an opening of what may be another good cave, which my

THE COLD MUMMY CAVE ON KAGAMIL ISLAND

THE PHOTOGRAPH SHOWS THE EXCEEDINGLY ROUGH NATURE OF THE OLD LAVAS IN WHICH THE CAVE WAS FORMED. IT ALSO GIVES SOME IDEA OF THE DIFFICULTIES OF APPROACH AND ESPECIALLY OF CARRYING THE COLLECTIONS OVER THE TOP OF THE CLIFFS.

HEAD OF A MUMMY, WARM CAVE, KAGAMIL ISLAND
REMARKABLY PRESERVED MONGOLOID PHYSIOGNOMY.

whole party craves to visit tomorrow. The Captain would like to leave—afraid of bad weather—but Commander Dempwolf, the head of the Alaska station, persuades him to stay.

Rich day. Warm shower, supper. No weariness. Of the officers and men of the boat every one would like to go with us tomorrow.

Thursday—Aug. 6. Up before 6. Sky fairly good, but a 30-mile gale from across the depression in the island, and water very rough. All our party gloomy, and not much appetite for breakfast. At one time the wind is so strong there is some fear the ship will drag, and probably have to leave. But about 9:00 things begin to moderate. At 9:30 gale over, and though still considerable waves we are able to leave with the large dory and a surf boat. No possibility of landing anywhere near second cave, so proceed to a partly sheltered cove about half a mile away. The coast here is nothing but huge boulders piled one upon another, with pools and leads of heaving water between. Landing even from surf boat difficult and risky, but somehow manage. Then up a very steep slope with high grass, over rough volcanic upland, then down another very steep pass into a hollow filled with rank vegetation and huge boulders among which there are deep unseen crevices, and finally on the bare big boulders of the beach, from which can be seen the opening of the new cave. Also along the route and especially in the hollows many gnats, and biting, though not as poisonous as at Uyak.

Climb over rocks into the cave, which is more spacious than the first, but cold, damp and dripping from the ceiling; also with barely light enough to see what confronts us. What we gradually perceive is desolate, as well as rich. Skulls and especially bones protrude everywhere from debris of skins, furs, mats and driftwood. The cave had contained several tiers of mummies laid on driftwood scaffolding, which in the course of time has collapsed. The cave has evidently not been visited by white man, but everything has been damaged or destroyed by foxes. For some years now traders have placed foxes on the island, left them there without food, and the animals lived partly on the mummies, and destroyed, even shredded, most of the coverings and mats. They even devoured or damaged, more or less, such bones as they could chew. The whole presented a devastation.

But there was no time to spare. At any moment there might set in another storm, or fog, and we will be called away.

HEAD OF A MUMMY, FROM KAGAMIL
THERE WAS A PERFORATION IN THE LOWER OUTER PART OF THE LEFT EAR, IN WHICH THERE IS A COLORED FEATHER FOR DECORATION.

So once more we set to work against time, with the help of Dr. Bingham, the ship surgeon, together with one of the officers, and one man from the ship. By 3:00 P.M. we had filled 24 sacks, besides which there was one large mummy still in a fair state of preservation, a heavy bag with cameras, torches, etc. The foxes, we found, had their holes and lairs under everything. There being much wood in the cave and the air being damp and cool, we tried to make fire, with the result that we were almost driven out by acrid smoke but could get no real flame.

MOVING COLLECTIONS FROM THE COLD CAVE ON KAGAMIL ISLAND IN 1936
OVER DIFFICULT TERRAIN. RELAYS PROVIDED THE ONLY POSSIBILITY OF TRANSPORTING THE MATERIAL. EVEN IN THIS WAY THE HALF-MILE TRANSFER TRIP TOOK NEAR TWO HOURS.

Aside of the skulls, bones and other remnants of mummies, there were a number of parts of war shields, several beautifully carved spoons, three unique inlaid ivory labrets, a shred of especially artful matting, a stone lamp, a few slate knives and whetstones, and many remnants of decorated mats, native cords and other articles.

SHRUNKEN JIVARO HEAD FROM ECUADOR
SHOWING THE SAME TYPE OF DECORATION (FEATHER IN THE EAR). THIS IS ONE OF THE MANY EXAMPLES THAT RELATE REMOTE AMERICAN CULTURES WITH ONE ANOTHER.

Our sandwiches, and coffee, were left in the dory—but there would have been

no time for them anyway. At 3:00 P.M. and before it was possible entirely to finish with the cave, word came from the outside that the weather was failing again and that we must hurry back to the boat. As there was no possibility of even the surf boat coming near to where we were, it was necessary to retrace our steps over the rough road to the cove,

CHILD MUMMY IN ITS CRADLE

FROM THE WARM MUMMY CAVE ON KAGAMIL ISLAND. LITTLE MUMMIES OF THIS NATURE, AS IS KNOWN FROM EARLY RUSSIAN RECORDS, WERE SUSPENDED FROM RAFTERS IN THE CAVE.

but now we had also the bulky collections. There was but one thing to do and that was to arrange to move everything by relays. I strung the party over the boulders at such distances that the sacks, etc., could be handled or safely thrown over from one to the other, the last man to pile everything on the nearest greater boulder; after which the whole process was repeated. It now started also to drizzle and the gnats were bad. There were but five of us, the rest having gone or been sent ahead, to bring

A FEMALE SKULL

TAKEN FROM THE HOT MUMMY CAVE ON KAGAMIL ISLAND. PROBABLY THAT OF A FAVORITE MEMBER OF A FAMILY, PERHAPS A FAVORITE WIFE, BURIED SEPARATELY, IN MOSS, IN A WOODEN DISH.

BURIAL OF A NEW-BORN INFANT, IN A WOODEN DISH

THE BONES ARE IN SOFT MOSS. THE OFFERINGS SEEN ARE A BIRD'S EGG AND WING. THE WHOLE WAS ORIGINALLY ENVELOPED IN A MATTING, SHREDS OF WHICH ARE STILL SEEN ON THE LEFT. FROM THE KAGAMIL WARM CAVE.

the lunch (which never came) and to keep in touch with the two boats which were riding out in the cove. A considerable difficulty was encountered on the steep slope upward—there was danger of both men and specimens sliding down, and no space to pile up the parcels of the end of the chain; but that, too, was overcome. The trip from the cave to our cove took over one and three quarters of an hour. Meanwhile, the rocks and grass got all wet, which made going more difficult. But the relays worked admirably to the end. No one got real tired out. The surf boat was manipulated into a little inlet between a couple of huge boulders, some of the boys from the ship held it with oars so that the swell would not throw it on the rocks, the parcels were relaid bit by bit to one of the boulders, from there tossed over to two men in the boat, and when somewhat more than half of the collections were on, the surf boat went out to transfer everything to the dory. It then came back, was loaded with the remainder, took ourselves, and by 6:00 P.M., with weather steadily roughening, we were once more on board the "Chelan," added our harvest to that of the previous day, saw everything covered and safely tied on the deck; and before we were through with our shower the ship was on its way to Unalaska, where we reached the next day. Meanwhile a wire was sent to the Alaska Commercial Company to have ready on the dock 22 old tierces. On arrival we found these on the dock, they were at once taken aboard, and within three hours everything was packed and safe. In six weeks it was without damage in Washington, and then, for over a month, there was the rare treat of unpacking and examining everything. And it proved a wonderful material.

Notwithstanding these collections, the

MATS, BAGS AND BASKETS FROM WARM MUMMY CAVE OF KAGAMIL ISLAND

THESE OBJECTS WERE FOUND BURIED WITH THE BODIES, EITHER OUTSIDE OF THEM OR WITHIN THE MUMMY BUNDLES THEMSELVES. THE BASKET IN THE CENTER IS OF EXCEEDINGLY FINE WORKMANSHIP, AND THE OBJECTS THROUGHOUT SHOW AN ASTONISHINGLY HIGH DEGREE OF NATIVE ART.

two caves on Kagamil remained "unfinished business"; besides which there was the possibility, backed by some hazy rumors, of still another such cave on the island. For this reason a second visit, thanks to the Coast Guard, was made to the locality in 1937, and a third in 1938. In these visits another large cave was found, but it was empty; the rough southwestern coast of the island and the southeastern point were explored, without result except the location of a small and not very old site in the lowland, with a large barabra depression on the flat part over the cliffs near the location of the warm cave; and several rock-shelters, with burials, were discovered in the cliffs to the east of the warm cave and excavated. Both the warm and the cold caves were finally quite exhausted, without adding materially to our previous collections; but in the warm cave, in the lowest parts of the "salt" deposits, there came to light the remains of a number of cremations; and under a large slab that lay in the middle beneath everything, there were revealed, undisturbed, the remains of a group-cremation of several individuals, doubtless slaves.

On both the 1937 and the 1938 trips other caves and rock-shelters, also, were located and explored. The field notes relating to all this read as follows:

June 17, 1937. On the small Coast Guard ship "Morris," Lt. A. J. Carpenter. Leave Unalaska in the morning for Veselov (corrupted to Wisslow) island or rock, 13 miles west from Dutch Harbor. Weather half fair, sea moderately rough, nevertheless felt. Ship anchors about one third of a mile off the rock. Lunch with crew of dory, and then to the volcanic pile. Grows forbidding as approached, black rough sides, a huge hideous vertical rent in midst to the seaward. No beach or cove. Have to fasten to rock itself on landward side, where water heaves least. The islet is found to be a mass of volcanic conglomerate, a ferruginous lava warty with inclosed cinders and rocks, very rough and steep; but the "warts" are hard and like welded in, so that all afford firm hold and enable us to "goat it" over the sides. Above half way up we find a shallow shelter under a ledge, and in this 3 lower jaws. Excavate to about 2 feet deep, find other bones and a number of cultural specimens. Have cleaned everything. Remains *Aleut.*

June 18–19. Reach Chernovski Harbor, Unalaska Island. On a long and broad gravel bar, between sea and harbor, decaying remains of a Russian-time Aleut village, and to the left of this an imposing older mound-site, with a 35 × 140 feet barabra depression on the top. In distance to right, under a cliff, a rock-shelter, and further seaward a cave in another cliff, now empty but once said to have had burials. Excavation in the rock-shelter yields a number of old Aleut burials. Explore coast for caves over four miles eastward, without result; and nothing of that nature known of elsewhere in the region by local sheep herders.

June 20. Quiet, but sky murky. Reach Nikolski, Umnak. Krukhov, an old native, tells about the "mummy cave" mentioned by Veniaminov, on Shiprock.

June 21. Reach Kagamil. Sea moderate, but a heaving surf. Find in our beach a little "haven" among the boulders, just large and safe enough for the dory. Boys eager. Work whole afternoon in the two caves—just gleanings—but among these a fine wooden labret. Drizzle all P.M.

June 22, 5 A.M. Lovely morning, and nearby volcanoes, Mt. Cleveland and Mt. Carlyle, in all pristine beauty, like huge almost supernatural great pure-white cones, within 10 miles of us; but begins to cloud up before I can bring up my camera.

Ashore, with all my boys and some officers and men from ship, right after

VOLCANOES SHISHALVIN AND IVANGTSKI ON ALASKAN PENINSULA

ON CLEAR NIGHTS, WHICH HOWEVER ARE RARE, THESE PRESENT A MAJESTIC APPEARANCE. THE SHISHALVIN, APPROXIMATELY 8000 FEET IN HEIGHT, OCCASIONALLY SMOKES AND LIGHTENS THE NIGHT WITH A PILLAR OF LURID LIGHT THAT REACHES TOWARD THE SKY.

breakfast. Explore crags between the two caves, and soon locate a rock-shelter with some old burials. Explore also to NW along rough coast—find caves, especially one—but nothing in them.

Rock-shelter proves exceptionally rich, full of bones and skulls, but mostly female. Of mats and other perishables but traces. Two bodies cremated—doubtless sacrificed slaves. Men from ship very helpful—none hurt, and everybody living adventure. Good calm day, though swell outside our "haven." Seals a few yards from bouldery shore pop up from kelp to watch the visitors. Beach smokes to-day in many places. Lunch among the rocks. A hungry fox comes near one of the men—is fed on sardines thrown to it—then curls down and goes to sleep. At times eery views of the volcanoes through mists. . . . Late P.M. return to Chernovski.

June 23. To-day to examine the Split-Rock isle near Kashega, reputed to have a "mummy cave" or shelter.

Reach Rock near 8:30. Is completely split crosswise—some earthquake. About 200 feet in maximum height, slopes of talus, steep cliffs. Climb on top of smaller part—find two skulls there, also a superficial skeleton, with some stone points. A couple more skulls on the grassy slopes. Larger portion has a number of caves and rock-shelters; the caves now empty, rock-shelters worth exploring. Excavate a deeper one on the SE side, find burials, also four new type stone lamps—two quadrilateral. Dig also on top—two more skeletons.

Have endeavored to climb, too, the larger part of the rock. Found only one possible way and that very difficult. But the survey people had been here and left hanging down a sash-cord with copper-wire core. With the help of this, three of us reached the top—only to find, when

AN EXCEPTIONAL VIEW OF SMOKING MOUNT CLEVELAND
SEEN LOOKING WEST FROM APPLEGATE COVE OPPOSITE KAGAMIL ISLAND. THERE ARE SCORES OF THESE GREAT VOLCANOES IN THE ALEUTIAN CHAIN. PROBABLY NONE OF THEM IS QUITE EXTINCT. THEY ARE RARELY REVEALED, BEING COVERED WITH MISTS.

wanting to descend, that near where anchored the cord had so rotted that it parts when tested. How it held while we were scrambling up is unexplainable. The top was very grassy, but showed traces of natives. This isle ('Split-Rock') was known to the natives as a former refuge, and also as a place where, on the top, there used to be some temporary habitations, and burials. Based on the native information to this effect, the rock was visited in 1928 by the Stoll-McCracken expedition for the American Museum of Natural History (N. Y.), and both parts of it were scaled, with the results of finding, on the top of the larger portion, aside of the depressions of old habitations, a "driftwood sarcofagus containing four 'mummies' "; and the location of a burial rock-shelter on the south end of the smaller portion, which gave a small collection of skeletal as well as other materials.[12]

Toward evening we tried to reach Shiprock, a great high isolated "rock" in the Umnak Pass, and came near—but current proved too strong for our facilities and so had to return. Seven days—much good fortune—but no mummies. . . .

[12] Reported by E. M. Weyer, in an article on "An Aleutian Burial," *Anthrop. Papers Am. Mus. Nat. Hist.*, 31: 217–238, 1929.

(To be continued)

THE DYNAMICS OF SNEEZING—STUDIES BY HIGH-SPEED PHOTOGRAPHY[1]

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SNEEZING, the violent expulsion of air from the mouth and nose, is an involuntary, reflex, respiratory act. It is caused by irritation of certain nerve-endings in the mucous membrane of the nose, or by stimulation of the optic nerve by a bright light.

By the early Greeks and Romans, a sneeze was considered a sign or omen from the gods. This venerable belief survives in the still wide-spread custom of saying "God bless you," or its equivalent, when a person sneezes. Sir John Lubbock,[2] in his "Origin of Civilisation and the Primitive Condition of Man," states that a sneeze was evidence that the sneezer was possessed by some evil-disposed spirit. To-day, in the field of public health, the activities of this "spirit"—bacteria and viruses in sneeze droplets—are recognized in the transmission of certain respiratory diseases.[3]

[1] Contribution No. 174 from the Department of Biology and Public Health.

[2] Sir John Lubbock (Lord Avebury). "Origin of Civilisation and the Primitive Condition of Man." Ed. 7. Longmans, London, 1912.

[3] W. F. Wells, M. W. Wells and Stuart Mudd. *Am. Jour. Pub. Health*, 29: 863, 1939.

FIG. 1. ARRANGEMENT OF SUBJECT AND APPARATUS FOR PHOTOGRAPHY.

FIG. 2. A VIOLENT SNEEZE, PARTIALLY STIFLED.

Recent investigations in air bacteriology and on air-borne infection have justifiably reopened the question of the role of air in the transportation of pathogenic microorganisms. Of the importance of droplet infection there seems to be little doubt, but the part played by the air-borne droplet nuclei, which result from the evaporation of droplets proper, has not been as clearly delimited. Experimentally, little is known of certain of the characteristics of sneeze droplets, although such factors as number, size, velocity and rate of evaporation are concerned in their dissemination and in the production of droplet nuclei. The importance of the definition of conditions which introduce bacteria into the air and the significance of the particle size and the resulting state of suspension in the air have been pointed out by Wells *et al.*[4]

In a preliminary study of droplet infection of air by sneezing, using high-speed, single-flash photography for demonstrating droplet production, Jennison and Edgerton[5] made certain incidental observations relative to the sneezing process itself. "Still" pictures have been complemented by high-speed motion pictures, and analysis of the records reveals a number of interesting points about the dynamics and external manifestations of this respiratory reflex. The records are of general physiological interest, as well as demonstrating graphically the possibilities of droplet infection.

Apparatus and Methods

The photographic technique utilized recent, unpublished modifications of the light sources and control instruments developed by Edgerton *et al.*[6,7,8] for

[4] W. F. Wells, *et al.*, American Public Health Association Year Book 1939–1940, pp. 99–101.

[5] M. W. Jennison and H. E. Edgerton, *Proc. Soc. Exp. Biol. and Med.*, 43: 455, 1940.

[6] H. E. Edgerton, K. J. Germeshausen and H. E. Grier. *Jour. Appl. Physics*, 8: 2, 1937.

[7] H. E. Edgerton, K. J. Germeshausen and

FIG. 3. MULTIFLASH METHOD FOR DETERMINING DROPLET VELOCITY.

stroboscopic illumination and high-speed photography, which technique substitutes an instantaneous flash of light for the relatively slow opening and closing of a camera shutter. The light illuminates the object to be photographed with an intense flash of short duration, "stopping" motion by providing an exposure-time so short that the object does not move any appreciable distance during exposure.

The light source, which was placed at the side of the subject's face away from the camera (Fig. 1), consisted of a light-tube in a parabolic reflector; illumination was produced by the discharge of a condenser through this tube. The light was placed in such a position that the droplets were illuminated with a dark-field effect, thereby standing out sharply even in daylight, indoors, and giving photographic images larger than actual droplet size, particularly when not in sharp focus. The intensity of the light is so great that it is unnecessary, indoors, to consider the amount of other light in making camera adjustments. A white screen in front of the subject reflected back enough light so that the side of the subject's face which was towards the camera photographed clearly.

For the single-flash "still" pictures, a 56 microfarad condenser, charged to 2,500 volts, discharged through a spiral, argon-filled light-tube. A photographically effective duration of flash (exposure-time) of about 1/30,000 of a second was found sufficient to "stop" most sneeze particles. For multiflash "still" pictures (used in determining droplet velocity), spiral light-tubes were used with 1-microfarad condensers at 3,000

H. E. Grier, *Photo Technique,* 1 (5): 14 (October), 1939.

[8] H. E. Edgerton and J. R. Killian, Jr. "Flash! Seeing the Unseen by Ultra High-speed Photography." Hale, Cushman and Flint, Boston, 1939.

FIG. 4. A VIOLENT, UNSTIFLED SNEEZE, NOT QUITE COMPLETED.

volts, and exposure-times of 1/100,000 of a second. Both types of "still" photographs were taken with an ordinary camera, with apertures of $f4.5$ to $f11$, on 9×12 cm. Verichrome film. It was convenient, but not essential, to have an electrical contact on the camera shutter; this contact set off the flash when the shutter (set at 1/100) was wide open.

For the motion pictures, a quartz-capillary light-tube was employed, with a 1-microfarad condenser charged to 1,200 volts. In the motion picture camera (without shutter) the film is moved past the lens at a constant, high speed. Each time the film has moved the distance occupied by one picture, the subject is illuminated by a flash of light. The time at which the flash occurs is controlled by a commutator attached to the film-driving mechanism. The duration of each flash is about 1/100,000 of a second, which effectively "stops" motion during exposure. A timing device in the camera records the film speed directly on the film. The sneezes were taken at speeds up to about 1,300 frames per second, on 35 mm panchromatic film.

Because of the lower light intensity, and for other technical reasons, very few *small* droplets showed up in the motion pictures and in the multiflash "still" photographs as compared with the numbers obtained with the single-flash technique.

Droplet velocities were obtained by three methods: *a*. The order of magnitude was estimated from single-flash photographs in which the exposure-time was long enough (1/30,000 to 1/15,000 of a second), so that the fastest droplets produced a path of measurable length on the film during exposure[5] (Figs. 2 and 7). This method is relatively inaccurate, however, because the exposure-time can not be determined precisely. This is a consequence of the electrical characteristics of the light source, which, after

quickly reaching a maximum brightness, tapers off in intensity, the point beyond which the light is photographically ineffective being only approximately determinable; *b.* Velocities were determined very precisely from measurements on the high-speed motion pictures (Fig. 9), the speed of which is known to within a fraction of a per cent.[6]; *c.* Multiflash "still" pictures also allow precise determination of velocity.[7] Two lights were used, each of which flashed once with a known time interval between the two flashes. This interval was determined by photographing, in the field of the sneeze, a disc spinning at known speed. A line on the disc appeared as an angle after consecutive flashes, and from the angle and the droplet displacement in the calculated time, droplet velocity was computed (Fig. 3).

Most of the subjects used were men, since they sneezed more readily, more violently and had less tendency to stifle the sneeze than women. Some of the subjects had colds, others hay-fever, and others were normal. Many of the sneezes were initiated by rubbing a little snuff into the nostrils. No water or other materials were held in the mouth. The subjects were asked to sneeze as naturally as possible but without consciously stifling the expiratory effort. There did not appear to be any marked differences between "normal" sneezes and those "artificially" induced, although the snuff often produced several spasms in quick succession.

Results

The observations are based on some 300 "still" pictures and 4 motion pictures, on 16 subjects at various times. While a sneeze consists of two stages—a sudden inspiration, followed by a forcible expiration—we have been concerned chiefly with the expiratory phase.

All subjects always had the eyes closed at the instant of expiration; often the

FIG. 5. A COMPLETED SNEEZE.

FIG. 6. SNEEZE FROM SUBJECT WITH A BAD COLD.

closing occurred coincidentally with the inspiration. This was not due to the light, which was coming from behind the subject. Furthermore, experiments with the light shining into the subject's eyes showed that there was a measurable lag between the light flash and the closing of the eyes. In sneezing, the eyes were closed at the time the light flashed, hence the closing stimulus occurred before the flash. Involuntary closing of the eyes appears to be part of the sneezing reflex (Figs. 2–8, 9).

At the inspiration, in most subjects, the head was involuntarily thrown back, and the mouth simultaneously opened wide (Fig. 9). Between the inspiration and expiration there may be an appreciable time interval, during which one or more false starts in expiration may be made. A typical expiratory phase consisted of a quick "down-stroke" of the head, a closing of the mouth and the forcible ejection of air and droplets. Usually the mouth was more nearly closed at the climax than in Fig. 9. In most cases the upper and lower teeth were closely approximated, as shown clearly in Figs. 4 and 5. The extent to which the mouth is closed, and particularly the approximation of the teeth largely determine the number and size of the droplets, that is, the efficiency of "atomization." Most of the droplets appear to originate from the saliva in the front of the mouth, more, and smaller ones, being formed in the air stream when the orifice is restricted (*Cf.* Figs. 4 and 9). The majority of sneeze droplets—before appreciable evaporation occurs—are less than 2 millimeters in diameter, and many are less than 0.1 millimeter, as determined from photographic enlargements, although in subjects having viscid mucous secretions from colds or hay-fever larger drops and masses are common, as a result of less effective "atomization" (Fig. 6).

Precise measurements of droplet speeds in violent sneezes have given "muzzle velocities" as high as 152 feet per second for some droplets, but speeds less than this are more usual. While this is the maximum rate we have recorded, we have not tried experimentally to determine the upper limit. For technical reasons, most of the smaller—and possibly faster—droplets did not photograph in the techniques which allowed accurate measurements of velocity.

Estimates of the pressures necessary to obtain the droplet velocities found have been calculated from thermodynamic formulas for air flow through orifices. A velocity of 150 feet per second would require a pressure of some 10 to 12 millimeters of mercury, not considering inertia of the droplets or friction. This pressure is about one fifth of the *maximum steady* pressure which a man can exert by blowing into a manometer. Since four times this pressure would be required to double the velocity, it is probable that even in violent sneezes, the fastest droplets do not have an initial velocity much over 300 feet per second, unless, perchance, the *instantaneous* pressure in a sneeze is markedly greater than about 60 millimeters of mercury.

The distance to which sneeze droplets will be expelled, and the distance to evaporation, depend upon droplet size, velocity, temperature and humidity of the surrounding air, and the moisture content of the particles. One would expect mucous secretions to evaporate less readily than saliva or water. Most droplets, because of their small size, are not expelled farther than two or three feet, under ordinary conditions, as shown both by photographs and by glass plates and culture dishes placed in front of the mouths (Fig. 7). Small droplets, at high velocity, quickly evaporate to produce air-borne droplet nuclei (Fig. 8); larger ones, as in Fig. 6, will be expelled farther, then fall to the ground.

The actual mechanism of droplet for-

FIG. 7. SNEEZING ONTO A CULTURE DISH TO COLLECT BACTERIA.

mation from secretions, in sneezing, is the same as that described and illustrated by Castleman[9] for the "atomization" of other liquids in an air stream. A portion of a mass of saliva or other secretion is caught up by the air stream, and, being anchored at one end, is drawn out into a fine filament. This filament is quickly cut off by the rapid growth of a dent in its surface, and the detached mass, being quite small, swiftly draws itself up into a spherical drop. The higher the air speed, the finer will be the filaments, the shorter their lives, and the smaller the drops formed, within limits. Droplet formation from a filament of saliva is illustrated in a previous paper,[5] and also is shown here, although not clearly, in Fig. 6, and in frames 70 and 71 of Fig. 9.

The photographs show that there is great variation in numbers of droplets with the type and with the violence of the expiratory effort. Violent, unstifled sneezes, particularly those in which the mouth was well closed at the climax, gave droplet numbers in the tens of thousands (Figs. 4 and 5). Stifling the sneeze results in fewer and in smaller droplets; this act may also tend to produce a greater velocity of expulsion (Fig. 2). On a culture dish directly exposed to sneeze droplets (Fig. 7), thousands of bacterial colonies will develop.

In both stifled and unstifled sneezes, the number of particles issuing from the nose—when, indeed, any could be detected from this source—was insignificant compared with the number expelled from the mouth. Furthermore, in the relatively few cases in which there were particles that appeared to be of nasal origin, excessive secretions of mucous were present in the nose, and larger *masses*, not small *droplets*, resulted from the sneeze. These facts are of more than

[9] R. A. Castleman, Jr. *Bureau of Standards Journal of Research*, 6: 369, 1931.

FIG. 8. DISTRIBUTION OF DROPLETS IMMEDIATELY AFTER EXPULSION.

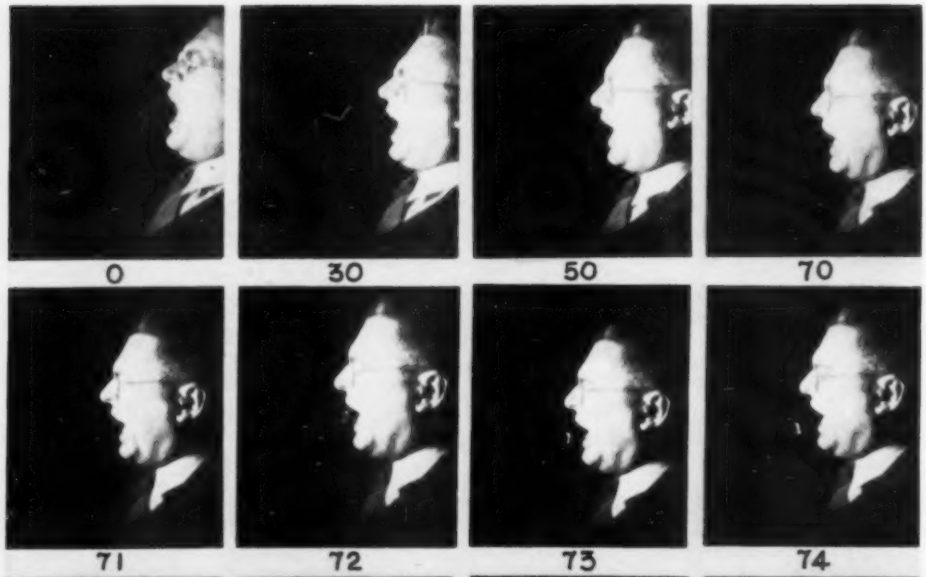

FIG. 9. SUCCESSIVE STAGES IN THE EXPIRATORY PHASE OF A SNEEZE.
SELECTED FRAMES FROM A HIGH-SPEED MOTION PICTURE HAVING INTERVALS OF 0.0008 SECONDS BETWEEN CONSECUTIVE FRAMES. NUMERALS REFER TO NUMBER OF TIME INTERVALS FROM THE START OF THE "DOWN-STROKE" OF THE HEAD. THE SMALL DROPLET IN FRAMES 71–74 HAS A VELOCITY OF 94 FEET PER SECOND; THE LARGER MASS IN FRAMES 72–80, A SPEED OF 61 FEET.

passing interest in relation to infection, because of the differences in the microbic flora of the two regions. Organisms of the mouth have usually received less attention than those of the naso-pharynx, in connection with both droplet infection and air-borne infection. But it is the *small droplets*—those originating in the mouth—which evaporate while in suspension in the air, and which therefore are of most direct importance in air-borne infection.

The fact that in most of our photographs of droplet expulsion no material could be detected coming from the nostrils, might result if particles from this source were caught in the blast of air and droplets from the mouth. However, records of early and late stages of sneezing usually confirm the negative observations made on the intermediate stages. While it does not necessarily follow that no air or particles were expelled through the nose, it appears that most of the pressure was released through the mouth. This is of physiological interest, in that Winton and Bayliss[10] state: "The sneeze . . . consists . . . of a sudden strong forced expiration, during which the glottis remains open, but the communication between pharynx and the mouth is closed by contraction of the anterior fauces, so that *the air from the lungs is driven entirely through the nose.*" (Italics mine.) This is obviously not the whole story, except possibly when weak sneezes are intentionally stifled, although we have observed that sometimes the involuntary closing of the mouth in a weak sneeze may result in *most* of the pressure being released through the nose. Experimentally it is difficult, in violent sneezes, to *prevent* most of the pressure from being released through the mouth, even if one tries. Our observations as to the end result are as stated by Best and Taylor:[11] "During the first part of the expiratory effort the way into the mouth is blocked by the elevation of the tongue against the soft palate, the blast of air thus being directed through the nose. *Later, the resistance offered by the tongue is removed, the air then escaping through the mouth.*" (Italics mine.)

The time involved in a sneeze is of interest, but not exactly determinable unless the beginning and end are taken rather arbitrarily. In Fig. 9, a sequence from the shortest expiratory phase obtained is recorded, taking as the beginning the start of the "down-stroke" of the head, and as the end the lowest point in this movement and the disappearance of the droplets from the photographic field. Partly for reasons of technique, and partly because of the type of sneeze, very few droplets show in this figure. These motion pictures were taken at 1,260 frames per second, and the expiratory effort as shown took 0.07 seconds. In motion pictures of three other subjects, the expiratory phase lasted longer —between 0.1 and 0.2 seconds.

Thus it is evident that the mechanics of sneezing are intimately bound up with the production, dissemination and even the potential infectivity of the resulting droplets. Until now it has been the impression that the pious aspiration uttered when a person sneezes was for the benefit of the sneezer, but obviously the ejaculation should be intended also for the protection of the potential victims. This germ-scattering performance certainly is nothing to be sneezed at!

[10] F. R. Winton and L. E. Bayliss. "Human Physiology." Ed. 2. P. Blakiston's Son and Company, Philadelphia, 1937.

[11] C. H. Best and N. B. Taylor. "The Living Body." Henry Holt and Company, New York, 1938.

THE HEART THAT FAILS

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EVERY announcement of a sudden fatality attributed to the heart creates the desire for a more intelligent comprehension of the mechanisms and reasons for such calamities. Commonly used expressions, such as "heart attack," "heart failure," "cardiac shock," "coronary attack," etc., are merely euphonious phrases; they do not satisfy as an explanation for inquiring minds. We read of the sudden extinction of life under a variety of conditions and circumstances: a distinguished citizen, apparently well, or certainly not significantly indisposed, is suddenly taken off at the dinner table or on the golf course; another quietly departs this life while asleep. Occasionally, despite the elaborate precautions which now attend administration of anesthetics, a patient's life is lost after a few whiffs of chloroform. Other noxious vapors, such as benzol and many toxic drugs and chemicals, act likewise. Furthermore, the extensive use of various electrical appliances in our homes, trades and professions has created a new hazard of quick cardiac death through accidental electrocution. The cardiac mechanisms by which life is extinguished are essentially alike in all these cases.

Consciousness and life are highly dependent on a continuous supply of oxygenated blood to the brain. Other organs of the body withstand complete absence of blood flow for considerable periods; but in the case of the brain it is only a matter of minutes or seconds before serious effects are produced. As every one is aware, blood is circulated by the pumping action of the muscular chambers of the heart, called the ventricles. If their pumping action ceases even for 3 to 5 seconds, temporary unconsciousness may occur. Failure to contract for 15 to 20 seconds can lead to twitchings or convulsions, while complete stoppage lasting 2 to 5 minutes is rarely followed by spontaneous recovery.

However, the types of fatal cardiac accidents which we are considering are not caused by standstill of the heart; on the contrary, the contractile efforts are significantly increased. What actually happens is that the rhythmic coordinated beats are suddenly converted into an incoordinate type of action, called ventricular fibrillation (fi-bril-lá-tion). It is of primary importance to form a mental picture as to what such a transformation involves.

Normally, the force for expulsion of blood from the heart is created by the simultaneous contraction of millions of microscopic muscle fibers which form the walls of the ventricles or myocardium. During ventricular fibrillation the muscle fibers still contract but in totally disorganized fashion, sometimes referred to as delirium of the heart. Fibrillary contractions are somewhat similar to shivering or convulsive contractions of skeletal muscles. Any one who has experienced or witnessed a severe chill or convulsion appreciates that vigorous and violent contractions can be functionally quite as useless as though the muscles remained at rest. In short, in cardiac or skeletal muscle, effective action demands not merely that muscles contract but also that they do so in a sequential and coordinated manner.

Fibrillation may also be compared to the action of an automobile engine in which the gas mixture in each of its eight cylinders is exploded very frequently but entirely at random. Such

an engine, like the fibrillating ventricles with their millions of tiny muscle cylinders, all firing out of phase, would consume more fuel but produce no useful work. In the case of the ventricles, this means that blood is not expelled, that pressures promptly fall to zero in arteries, and that death follows in 6 to 8 minutes, owing to anemia of the brain.

While the real cause of sudden cardiac death has continued to baffle physicians until comparatively recent times, ventricular fibrillation has been known to physiologists since its recognition by Ludwig in 1850. This lag in application of knowledge has been due to the fact that ventricular fibrillation is a physiological disorder, incapable of recognition, postmortem. It was only through the development of electrocardiography with the shuttling of problems and discoveries between the experimental laboratory and the bedside that clinical diagnoses have become possible.

During the 90 years which have elapsed since Ludwig's description of fibrillation, physiologists have directed their talents toward the solution of many problems. Some of the more important ones are (1) the interpretation of the nature of the fibrillating process; (2) the establishment of the conditions which are responsible for its initiation, (3) the development of methods for defibrillating the ventricles and restoring normal beats before the brain has been irretrievably damaged, and (4) attempts to render the ventricles less susceptible or refractory to fibrillating agents.

Nature of Ventricular Fibrillation

Coordinated, effective action of the ventricles is normally achieved, through an ignition system, somewhat as in an automobile engine. Seventy-two times per minute—more or less— combustible material in the millions of tiny muscle cylinders is exploded by a brief electrical impulse. This impulse is generated in a small knot of tissue in the right auricle, known as the *sinus node*. It is distributed to the ventricles over a special system of muscular wires and in such a manner that it fires all the muscle fractions approximately at the same time. The simultaneous explosion of combustible material results in the vigorous contraction of the ventricles as a whole. It is amply established that, during fibrillation, the electrical impulses no longer travel over this organized route, but spread at random and in a disorganized fashion throughout the myocardium. In so doing, they still cause contractions of the muscle fractions; but entirely in a haphazard manner.

Opinions are divided as to how this disorganization is brought about. According to one school of observers, a large number of new ignition centers are created throughout the myocardium, each of which emits a rapid succession of electrical impulses which spread wherever they can. In other words, the heart is no longer dominated by a single distributor of electric impulses, but by a great number scattered through the heart. In consequence, a conflict of excitation and an asynchronous contraction of the muscle fibers result. According to another school of observers, a condition is suddenly created which permits electrical impulses to escape from an original path, with the result that unrestrained impulses wind and weave way through the myocardium, return more or less to their starting point, traverse the path again, thus establishing perpetual circuits of electrical impulses called "circus rings." In their travel they excite and explode the muscle cylinders which have recovered from a previous contraction. In effect, the original impulses keep on circulating and maintain the fibrillating condition as long as combustible material and oxygen remain availabe. Which of these conceptions is more probably correct? I can answer the query best by reference to some of my personal observations. As a member of

a committee on electric shock, organized in 1928 under the leadership of Professor Howell, one of my projects involved a more detailed study of the fibrillating process by electrocardiographic and cinematographic recordings. These studies demonstrated that, in the mammalian heart, fibrillation is not a constant phenomenon but involves an evoluting series of changes from the moment that it begins until it ceases in 30 to 45 minutes. If the movements of the ventricles are carefully watched for the first two or three minutes or, better still, are photographed and studied through slowed motion pictures, it is seen that the contractions gradually change from undulatory waves to tumultuous convulsive motions and then to fine rapid trembling movements. Analysis shows that, with this transformation of movement the ventricular surface is progressively divided into smaller and smaller areas, which contract faster and faster, each with its own tempo. This is confirmed by tapping electrical impulses at different spots by means of small wicks and recording the electrical potentials so derived by a delicate string galvanometer. In recent studies of this sort, I was able to show that the electrical excitations in three or four different spots bear no relation to one another, and that their frequencies are different. For example, it was found in one experiment that four areas which normally were excited simultaneously 90 times per minute were now excited respectively 840, 675, 600 and 480 times per minute during the tremulous stage. No unitary center or single loop of electrical impulses could produce such results.

Obviously any conception or theory as to the nature of fibrillation must include an explanation of these rapidly evoluting changes in the fibrillating process. We must either believe that more and more centers for excitation arise throughout the myocardium during the first two or three minutes—which is unlikely—or we must adapt the theory of "circus excitation" originally advanced by Professor Garrey of Vanderbilt University to the facts. My own observations incline me toward the belief that at the start, several impulse-fronts sweep over large portions of the ventricles, possibly over muscle bundles. These impulses return more or less to their starting point, approximately retrace their paths, but each time the pathway is somewhat more restricted. After traveling over such circuits four or five times some impulses are extinguished through collision or are otherwise blocked. Separated from the original circuits they form shorter ones, which, in turn, are blocked at the margins. This process continues until the few original long circuits are subdivided into innumerable shorter circuits of shuttling impulses which repeatedly weave their way through small muscle masses. The shorter the circuit, the more frequent the tempo becomes. Such a conception would account for the changing modes of contraction, the formation of smaller and smaller areas, the general speeding up of contractions and the differing rates of excitation in different areas. Regardless of the ultimate correctness of this conception, it may be stated that its formulation as a working hypothesis was responsible for the trial of a new method for defibrillating the ventricles, to be discussed later.

After intervals of about 2 to 4 minutes, still another factor enters into the evolution of the fibrillation process. The contractions become unmistakably weaker and the wavelets travel more slowly. This marks the beginning of the atonic phase. Gradually one area after another ceases to contract, and in 30 to 45 minutes the whole heart has come to rest. Whereas the evoluting changes which precede this atonic phase are attributable to changes in the delivery of electrical impulses, those which occur during this stage are due chiefly

to lack of oxygen. The individual muscle cylinders still have the fuel and they receive the spark, but they fail to contract vigorously owing to the deficiency of oxygen so necessary for combustion. This anoxia, as it is called, develops because, with the very onset of fibrillation, no blood is pumped into the aorta and no blood flows through the coronary arteries which supply the myocardium. As the small reserve store of oxygen attached to the red coloring matter of heart muscle is eventually exhausted, all contractions cease.

The Initiation of Fibrillation

An acceptable theory of ventricular fibrillation must explain not only the nature of the process after it has become established but the mechanisms which allow it to start. Heretofore we have had only vague suggestions as to why some electrical currents cause fibrillation and others do not. A year ago no one had even attempted to offer a logical explanation as to why it starts spontaneously after coronary occlusion or injection of certain drugs. There is no doubt, however, that an understanding of the process involved or even a knowledge of the coefficients necessary for its induction would go far toward lifting experimental studies from an empirical to a scientific plane. Frankly, we are not yet in a position to offer a satisfactory conception of the ultimate mechanisms concerned in starting ventricular fibrillation. But recent discoveries defining the conditions for its precipitation do direct the analysis into narrower channels.

We have stated that fibrillation may follow coronary occlusion, use of various drugs and chemicals—of which chloroform is merely an example—and from passage of electric currents through the heart. It may now be added that it occurs occasionally from mechanical insults to the heart; indeed, it is probable that sudden contusions of the chest, heavy blows of pugilism or entry of a bullet are not without danger in causing sudden death from fibrillation. Personal interest in the subject of fibrillation was originally aroused by the desire to conserve laboratory animals in experimental work, both as a humane measure and a matter of expense. In 1919 a series of investigations was begun to determine how the action of the heart is modified by valvular lesions and other pathological conditions. In these experiments it was necessary to pierce the ventricles of anesthetized dogs with an instrument for recording internal cardiac pressures. Such experiments demonstrated that ordinarily the heart has a remarkable resistance to injury and to severe manipulation. Occasionally, however, the piercing of the heart or an apparently trifling insult led to fibrillation. It occurred in hearts of young and old dogs alike; in hearts that were well or poorly nourished. Various measures were tried to avoid such accidents or to restore normal heart beats; but none proved useful. The question naturally arose as to what determines whether an insult to the heart proves innocuous or leads to fibrillation. We certainly can not be content with its assignment to luck or chance.

In 1923, entirely unrelated experiments yielded a clue as to the reason for such accidental fibrillations. They were designed to test the reactions of the dog's ventricles to brief single induction shocks. It was supposedly well known to physiologists that such shocks cause premature beats when they are applied while the ventricles are relaxing, but are without effect while they are contracting. To my surprise, and contrary to orthodox teaching in physiology, it was discovered that a shock administered during the last moments of contraction also caused a delayed premature beat. In such tests it was a great disappointment when such a shock occasionally caused fibrillation and terminated the

experiment. Similar results have since been reported by physiologists at Columbia University. In view of the fundamental importance of such observations, we studied this problem more carefully. During the past year we have demonstrated unequivocally the following facts:

1. A momentary condenser, induction or galvanic shock, or a single sine wave of a 60 cycle alternating current fibrillates the ventricles, provided it is strong enough and coincides with the last .05 to .06 second of contraction which we have called the vulnerable period of the ventricles. Applied at any other moment of the cardiac cycle an electrical shock is innocuous, no matter how strong.
2. Local application of such shocks suffices; passage of current through a large part of the myocardium is not necessary.
3. The capacity to fibrillate is inherent in heart muscle; it requires no sensitizing or adjuvant action of nerves or hormones to induce it, although admittedly these may affect the threshold.
4. More prolonged direct or alternating currents can fibrillate either because an effective portion of such a current coincides with the vulnerable period of a beat or because they evoke centers which spontaneously release impulses, one of which falls during the vulnerable phase of a beat.
5. Under certain circumstances, such natural stimuli may be strong enough to induce fibrillation.

Into what channels of thought have these discoveries led us in explaining the onset of fibrillation? The demonstration that a stimulus must fall during the vulnerable period in order to start fibrillation indicates clearly that some fractions of the myocardium have become excitable again before the end of systole, that is, before the moment when ejection of blood from the ventricles ceases. Such a theory was developed by the writer in 1927. It is obvious, as Dr. King of Columbia University has properly emphasized, that such an asynchronous cessation of contraction in the muscle cylinders is basic to any concept as to the initiation of fibrillation. But it does not go far enough; something is involved in addition, for, if the stimulus is not strong enough, only one premature beat is induced, presumably through excitation of the same excitable fractions. What this "something" is remains speculative; but we now feel reasonably certain that it must be in the nature of some modification which permits a premature excitation wave to reenter. We are trying to obtain further information as to whether this may be due to local blocking actions of the stronger shocks, to initial excitation of a larger number of fractions and formation of broader wave fronts or to the contingency that the interventricular septum or opposite ventricle are excited over natural or abnormal pathways. The question remains, what are the coefficients which determine induction of an apparently spontaneous fibrillation after use of certain chemicals or drugs and during coronary occlusion? We have not studied the former, but our most recent experimental observations suggest an explanation as to how it is produced after occlusion of a coronary vessel.

We may reiterate that, in order to induce fibrillation, we must have an effective stimulus which may be of brief duration but which must coincide with the vulnerable moment of systole. In the case of fibrillation which occurs spontaneously during coronary occlusion, the stimuli must originate in the heart. Now, it is well known that interruption of blood supply to an area causes the development of centers emitting occasional electrical impulses that are very much like brief induction shocks. This is proved by the frequent occurrence of premature systoles after coronary occlusion both in experimental animals and in man. According to our conception, fibrillation would result if one such spontaneously developed stimulus fell during the vulnerable period of a normal beat or that of a premature beat induced by discharge from another center. In addition to its proper incidence, the spontaneous stimulus must also be strong

enough. This is probably not the case when the myocardium is normal. However, we have found very recently that lack of blood supply greatly increases the irritability of myocardium, so that a very weak artificial shock suffices to cause fibrillation. We therefore believe that a natural electrical impulse discharged at the proper moment is sufficient in strength to fibrillate both ventricles when the tissue is hyper-irritable as a result of myocardial anemia.

Revival of Fibrillating Ventricles

A considerable mortality from ventricular fibrillation due to coronary occlusion and to accidental electrocution resulting from defects in electrical appliances or their improper use, has stimulated scientists to seek practical means for defibrillating the ventricles and restoring normal beats. However, the present state of achievement owes quite as much to fundamental discoveries made during the course of other investigation as it does to experiments designed particularly for this purpose.

Older investigators had clearly demonstrated that the ventricles of all animals are not equally susceptible to fibrillating agents. Fibrillation is difficult to induce in cold-blooded hearts but easily produced in those of mammals. The ventricles of many smaller mammals, such as mice, rats, cats, rabbits, hedgehogs and monkeys frequently recover spontaneously; whereas the ventricles of guinea pigs, dogs, sheep, goats and man do so rarely, if at all. Hence, the fatal nature of the process in animals which do not recover spontaneously was formerly stressed. The conception that such ventricles can not be defibrillated was soon shown to be erroneous, for it was proved that it could be stopped in excised hearts through cooling or cutting the muscle into smaller pieces. Admittedly, a wide hiatus exists between such abolition of fibrillation in excised hearts and the revival of hearts in the body. Nevertheless, these fundamental demonstrations served their purpose in recreating the hope that methods for resuscitation of such hearts might be discovered.

The experiment of Hering, a German physiologist, consisting in the abrogation of fibrillation in the perfused heart by addition of potassium chloride and the restoration of vigorous normal beats through subsequent irrigation with Locke's solution has frequently been repeated in physiological laboratories. It was therefore natural for investigators to employ this agent to check fibrillation of hearts within the body. Since the natural circulation is discontinued, the problem arose of devising means for transferring a potassium solution to every unit of fibrillating muscle and for removing or neutralizing it with calcium chloride after fibrillation had ceased. D'Halluin, a Belgian physiologist, reported success in 1904 from injecting potassium chloride solution into a jugular vein and spreading it through the myocardium by massage. In 1929, Hooker of Johns Hopkins University succeeded in reviving fibrillating ventricles by forcing a weak solution of potassium chloride into a carotid artery under pressure, while I stopped fibrillation by injecting stronger solutions directly into the ventricular cavities. Subsequent application of a calcium chloride solution by the same methods sometimes revived spontaneous beats.

While such occasional revivals constituted a technical achievement of which we were once justly proud, they were certainly inadequate. Looking back, they served their chief and broader purpose, not in their practicability, but in defining more clearly the requirements for successful revival. These seem to be (1) that every vestige of fibrillation disappears, (2) that adequate centers survive for the generation of spontaneous impulses, (3) that not too many and preferably only one center exists and (4) that the muscle fractions excited from

that center are capable of responding with vigorous contractions. As we review our experiments in which potassium and calcium were successively employed, we are not surprised that failures frequently occurred; it is rather remarkable that success was experienced so often. Potassium ions unquestionably abolish fibrillation, but they depress contractions and pacemakers as well. Subsequent use of calcium ions enhances contractions but it awakens so many centers of excitation that the ventricles easily revert to fibrillation. This is also a drawback to the use of adrenalin—a powerful cardiac stimulant so often used by surgeons to encourage revival of the heart.

A significant advance in resuscitation of the fibrillating ventricles occurred with the demonstration by Hooker and his associates in 1933 that a strong alternating shock, not more than 5 seconds in duration, abolishes fibrillation and restores normal beats. These investigators were not pioneers in the use of the method of countershock, but, as is often true in science, the greater credit belongs to those who place a discovery on a substantial foundation and give it currency in scientific thought. These investigators also showed that fibrillation of the heart in the closed chest can likewise be abolished by sending a strong countershock current through the heart by electrodes applied to the chest. Williams and his associates at Columbia subsequently demonstrated the effectiveness of extremely strong shocks in rams, which are more nearly comparable in weight to man.

Unfortunately, the method has its limitations, which were clearly recognized by its discoverers. Revival rarely occurs when the ventricles have fibrillated more than two minutes. We discovered that when fibrillation follows coronary occlusion it is not effective even within this short time-span. In order to be practical even for experimental purposes, it was necessary to extend the possible period of revival. This we feel constituted our contribution to the problem. The change in technique which made this possible was slight, but the physiological basis which it involves is a broad one and was suggested by entirely unrelated experiments.

In the first place, we had observed that failure to revive the ventricles after two or more minutes of fibrillation was generally not due to difficulty in abolishing fibrillation but rather to the weak character of the coordinated contractions resumed. These feeble beats either ejected no blood or only insignificant quantities, arterial pressures failed to rise and the heart quickly became more hypodynamic or reverted to fibrillation.

Secondly, the discovery was made during our study of coronary occlusion that the area affected by ligation of a coronary branch rapidly lost its power of effective contraction. Thus, the idea began to dawn that the "two-minute time limit" for revival after fibrillation is due to a similar interruption of the coronary flow. Vigorous contractions can not occur in the absence of a supply of oxygenated blood. Consequently, when the ventricles are defibrillated by a countershock, the contractions are necessarily very feeble. It also became clear as to why the method seemed so ineffective in abolishing the spontaneous fibrillation developing after coronary occlusion; in such cases large sections of the myocardium have been deprived of their blood supply even before fibrillation has begun.

The indications were obvious; the myocardium must be supplied with oxygenated blood *while fibrillation continues and before a countershock current is applied.* This we did by manual compression of the ventricles, about 40 times per minute, so that their cavities are emptied each time. This process, called cardiac massage, causes a material elevation of arterial pressure and forces blood through the coronary arteries supplying the myocardium. During the year which has passed, we have made an-

other slight but material change. While the ventricles are being rhythmically compressed, the aorta is partly constricted with the fingers, so that a larger proportion of the blood squeezed from the ventricular cavities is forced through its walls by way of the coronary arteries which arise central to the digital constriction.

During the course of experimental work in which the heart is exposed, my associates and I have witnessed over 1,000 revivals in all kinds of fibrillation in dogs weighing up to 18 kilograms. Indeed, the procedure is now standard in the laboratory, and its routine use has contributed significantly to the successful completion of complicated experiments on the coronary circulation.

Occasionally, however, the method fails because one or several shocks are unable to defibrillate the ventricle completely. A small area may persist in fibrillation, and we are inclined to believe that the interventricular septum continues to fibrillate even when it is not apparent from surface observations of the heart. Apparently, in order to defibrillate the ventricles completely a shock must pass through every fraction of fibrillating tissue in sufficient strength. If the hearts are large or the electrodes are not properly placed, an effective current may fail to pass through certain parts. The deep internal interventricular septum is particularly protected. Various expedients have been tried to overcome this emergency. We have increased the size of electrodes and intensified the countershock current used without great success. Moreover, very strong currents often spread to the auricles and start their fibrillation, an undesirable feature when the ventricles do revive. Beck and Mautz, who have adopted our modification of the countershock method in the laboratory of experimental surgery, were particularly impressed with the difficulty of completely defibrillating hearts of large dogs. They found that injection of small doses of procaine into the ventricular cavities, previous to the use of massage and countershock, was apparently helpful in abolishing such residual areas of fibrillation. Unfortunately, this drug depresses muscular contractions and unless cautiously used prevents the resumption of vigorous beats. For this reason, we have questioned its value as an adjuvant to countershock.

In investigations during the past year, supported by the John and Mary R. Markle Foundation, the need arose for a method which would revive fibrillating hearts promptly, certainly and repeatedly, and which did not involve the use of drugs or chemicals. With the development of our view outlined above that the fibrillation process evolutes by causing reentrant excitations in more and smaller areas, the thought arose that the evoluting process might conceivably be reversed by a *rapidly repeated series* of A.C. shocks. In this way, larger and fewer fibrillating areas might again be formed. Eventually the longer circuits created might be completely interrupted and the fibrillation stopped *without the necessity of having the countershock current traverse the entire myocardium.* If this were true, weaker currents might be employed, defibrillation would be more certainly accomplished, and auricular fibrillation more generally avoided.

Extensive tests proved that this can be done by applying a succession of 3 to 7 brief A.C. shocks of about 1 ampere in strength, at intervals of about 1 second. Each shock appears to convert the fibrillation into a coarser type until a final shock results in complete arrest of the ventricles. We have called the procedure *serial defibrillation.* The advantages are: (1) an effective current does not need to traverse each fibrillating fraction; it acts by merging excitation rings, (2) the ventricular septum, difficult to reach in larger hearts, is defibrillated, (3) weaker currents which are not so apt to start auricular fibrillation and have no after-effects on the ventricles can

be used, and (4) the certainty of recovery is increased. So far, the method has proved remarkably successful. During six months trial, tabulations of 328 tests showed only a single failure. Indeed, we now regard death from fibrillation in dogs whose hearts are exposed as evidence of negligence or bad technique.

The practicability of the countershock method in cases of human ventricular fibrillation due to electric shock or coronary occlusion naturally deserves careful consideration. It appears to us that, while we seem to be on the threshold of success, formidable barriers are blocking that threshold. These must be frankly recognized, for it is as important to emphasize the limitations of new discoveries as it is to herald their success. Only a few of the difficulties which confront us can be discussed in the space available. The practical utilization of the countershock method is thwarted by the difficulty of utilizing currents which are adequate to defibrillate the human heart. It is exceedingly doubtful whether 110 volts A.C. house current generally available, can yield sufficient current to defibrillate larger human hearts even when electrodes are applied directly. In rams, somewhat comparable in size, Spencer, Ferris, King and Williams found it necessary to use 3,000 volts giving currents of 25–30 A. in order to achieve defibrillation through electrodes applied to the chest. The danger to patient and operator alike—not to mention their general availability—is apparent. Our observations that weaker serial shocks seem to be efficacious, reawakens the hope that this procedure may require less current for revival of human fibrillating hearts. Unfortunately, the difficulty does not end here. Any method of countershock employed by itself must not be expected to be effective beyond two minutes of fibrillation and perhaps less. To rush a patient to a hospital, institute artificial respiration, open the chest aseptically and massage the heart within 15 minutes requires a degree of optimism which physiologists find it difficult to share with surgeons. This, however, is certainly the maximum interval after which revival of brain function can be expected; indeed, it is highly probable that mental deterioration would occur within a much shorter period of complete cerebral anemia.

For the present, the hope for revival is apparently restricted to patients who develop fibrillation on the operating table, and particularly those in whom the heart has already been exposed. Prompt utilization of massage and serial countershock should prove effective in such cases. To meet such contingencies, cardiac surgeons generally will probably soon follow the lead of Dr. Beck of our surgical department in adding appropriate countershock apparatus as standard equipment in their operating rooms.

We see little prospect that revival methods so far developed will have great prospect of success in restoring hearts that fibrillate as a result of coronary thrombosis. Experimentation has shown clearly that such hearts can not be revived unless the occlusion is first removed and the ischemic area flooded with arterial blood by massage; two conditions difficult to realize in man. While the revival of human hearts from fibrillation must not be regarded as hopeless, we must not allow ourselves or others to become too optimistic. Indeed, it seems more profitable for the present to direct research talents toward the task of attempting to render the heart less sensitive to fibrillating agents or even better of making it completely refractory.

Sensitization and Desensitization of the Ventricles to Fibrillation

The literature contains a number of experimental reports which support the general belief that the tendency of the ventricle to fibrillate can be increased or decreased by nervous or humoral agents as well as by certain drugs. The results of our studies indicate, however, that this has not been demonstrated as

critically as investigators generally believe. Space is lacking to do more than enumerate the types of studies upon which such conclusions are based. They are:

1. Comparison of time elapsing between coronary occlusion and the incidence of fibrillation, —a very variable period according to our experience.
2. Determination of differences in strengths or durations of a current required to induce fibrillation; a very erratic method, because any current which lasts more than .05 second creates a number of factors which may induce fibrillation fortuitously.
3. Comparisons of the durations of fibrillation in the cat; a very variable interval according to our experience and that of others.

That such tests are inadequate is indicated also by the contrary effects imputed to the same agents or processes by different investigators. Thus, activity of the accelerator nerves or adrenalin is claimed both to increase and to decrease the resistance of the ventricles to various fibrillating agents.

We have only recently suggested a new criterion based on our proof that fibrillation is due to application or release of an effective stimulus during the vulnerable phase of the systole. It consists in measuring the resistance of the ventricles to fibrillation—or tersely, the fibrillation threshold—by the strength of a brief shock which, applied during the vulnerable period, just suffices to fibrillate. We believe that it takes into account the irritability of responsive muscle fibers and the eventual additional state which determines that the premature impulses reenter and begin to circulate.

Many technical and experimental details need to be overcome, however, before such a simple test could be put into practice. The most suitable, and easily measurable, electric shock had to be decided upon. Special apparatus had to be designed in order to apply such shocks with certainty to an occasional vulnerable period. After considerable experimentation we chose the milliampere value of rectilinear shocks .01 to .03 second in duration, which, when applied during the vulnerable period, induced fibrillation, as a measure of the fibrillation threshold. By applying our method of defibrillation, repeated tests could be made on the same animal before and after treatment.

Since the determination of each threshold required 30 minutes, and the effects of a drug could not be determined in less than 5 or 6 hours, it was necessary to determine how constant the threshold remained after successive defibrillations over such a long period. It was in fact at one time feared that the alterations in pressure and chemistry of the blood, or the effects of countershock currents on the fibrillation process itself might prevent use of this mode of testing. Indeed, most of our time was spent in discovering the factors which yield inconstant threshold values and in inventing ways in which to avoid or circumvent them. Among the factors we have learned to control are the temperature of the ventricular surface, the careful placement of electrodes on the same spot, the avoidance of polarization and other effects of repeated currents, etc. In addition, it proved necessary to revive the ventricles quickly from each fibrillation and to allow an equilibration period not less than 15 minutes after each recovery before making another test.

With attention to these and other numerous details, we have evolved a procedure by which reasonably constant fibrillation thresholds can be obtained over a period of five or six hours in untreated dogs. Employing this method, we succeeded in showing that the fibrillation threshold is tremendously reduced during coronary occlusion, and that procaine tends to raise the threshold. The procedure is now perfected so that the actions of many drugs and physiological influences can be tested in a systematic manner.

THE PRESS IN AMERICAN CITIES[1]

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WHAT is an American newspaper? How do the newspapers in cities that rank high in welfare differ from those in cities that are, relatively, low in welfare?

To answer these questions, a count was made of the amount of space (excluding advertisements) given to each of the topics listed below in one or more issues of one or more newspapers for the six week days, September 13 to 18, 1937, in Augusta (Ga.), Berkeley, Birmingham, Charleston (S. C.), Chester, Colorado Springs, Columbus (Ga.), East St. Louis, Evanston, Glendale, Grand Rapids, High Point, Kalamazoo, Lewiston (Me.), Manchester, Meridian, Minneapolis, Mobile, Oakland, Pasadena, Rome (N. Y.), San Diego, San José, Santa Barbara, Seattle, Springfield (Mass.), Tucson and Woonsocket. In all, 135 issues of newspapers were inventoried. The topics were: (1) foreign news: war; (2) foreign news: not war; (3) education: general U. S.; (4) education: local; (5) art: general U. S.; (6) art: local; (7) music: general U. S.; (8) music: local; (9) crime: general U. S.; (10) crime: local; (11) local society, clubs, etc.; (12) local personal items; (13) athletics and sports; (14) radio programs; (15) science; (16) intelligence tests; (17) bridge; (18) crossword puzzles; (19) question-answer; (20) stories; (21) story pictures; (22) comic strips; (23) cartoons; (24) weather; (25) stocks and bonds; (26) commodities.

We compute for each city the percentage which the space accorded to each of these topics is of the space accorded to them all. There is a considerable variation among the 28 cities in almost every one of these percentages. To reduce the influence of special local events, we take only the 24 cities for which records of three or more days of the week, including at least one day from each half of the week, are available. The spread in percentage required to include two thirds of these 24 cities are as follows:

Foreign, war: 7.3 down to 3.3, a ratio of 2.2 to 1.
Foreign, not war: 4.3 down to 2.0, a ratio of 2.1 to 1.
Education, art and music, general: 2.0 down to .4, a ratio of 5 to 1.
Education, art and music, local: 2.35 down to .51, a ratio of 4.6 to 1.
Crimes outside the neighborhood: 2.4 to .75, a ratio of 3.2 to 1.
Local crimes: 1.9 to .65, a ratio of 2.9 to 1.
Local associations, clubs, society and personal items: 14.8 to 7.6, a ratio of 2.1 to 1.
Athletic sports and games: 33.6 to 22.55, a ratio of 1.5 to 1.
Radio programs: 5.05 to .73, a ratio of 6.9 to 1.
Science: .70 to .105, a ratio of 6.7 to 1.
Intelligence tests: .10 to 0.
Contract bridge lessons, problems, etc.: a ratio of 1.15 to 0.
Cross-word puzzles: .265 to .13, a ratio of 2 to 1.
Questions and answers: 3.80 to .57, a ratio of 6.7 to 1.
Stories: 7.3 to 3.7, a ratio of almost 2 to 1.
Story pictures: 8.35 to 2.55, a ratio of 3.3 to 1.
Comic strips: 16.7 to 8.15, a ratio of 2 to 1.
Cartoon: 6.1 to 2.8, a ratio of 2.2 to 1.
The weather: 1.65 to .48, a ratio of 3.4 to 1.
Stocks and bonds: 11.4 to 1.7, a ratio of 6.7 to 1.
Commodity markets: 4.6 to .75, a ratio of 6.1 to 1.

What do the differences in the contents of the newspapers of cities signify? In particular, how are they related to the quality of the population and its life? I have determined for each city a score, G, for the general goodness of life for good people, which is a weighted average of the thirty-seven items listed below. Fourteen of the cities were chosen for the investigation because they ranked at or

[1] The investigation reported in this article was one small part of a project supported by a grant from the Carnegie Corporation.

near the top of the 310 cities in the United States having 30,000 or more population in 1930. Fourteen were chosen because they ranked at or near the bottom in this G score.

CONSTITUENTS OF THE G SCORE OR INDEX

Items of Health

Infant death-rate reversed; General death-rate reversed; Typhoid death-rate reversed; Appendicitis death-rate reversed; Puerperal diseases death-rate reversed.

Items of Education

Per capita public expenditures for schools; Per capita public expenditures for teachers' salaries; Per capita public expenditures for textbooks and supplies; Per capita public expenditures for libraries and museums; Percentage of persons sixteen to seventeen attending schools; Percentage of persons eighteen to twenty attending schools; Average salary, high-school teacher; Average salary, elementary school teacher.

Items of Recreation

Per capita public expenditures for recreation; Per capita acreage of public parks.

Economic and "Social" Items

Rarity of extreme poverty; Rarity of less extreme poverty; Infrequency of gainful employment for boys 10–14; Infrequency of gainful employment for girls 10–14; Average wage of workers in factories; Frequency of home ownership (per capita number of homes owned); Per capita support of the Y. M. C. A.; Excess of physicians, nurses and teachers over male domestic servants.

Creature Comforts

Per capita domestic installations of electricity; Per capita domestic installations of gas; Per capita number of automobiles; Per capita domestic installations of telephones; Per capita domestic installations of radios.

Other Items

Per cent. of literacy in the total population; Per capita circulation of *Better Homes and Gardens, Good Housekeeping* and the *National Geographic Magazine;* Per capita circulation of the *Literary Digest;* Death rate from syphilis (reversed); Death rate from homicide (reversed); Death rate from automobile accidents (reversed); Per capita value of asylums, schools, libraries, museums and parks owned by the public; Ratio of value of schools, etc., to value of jails, etc.; Per capita public property minus public debt.

The cities at or near the top were: Berkeley, Colorado Springs, Evanston, Glendale, Grand Rapids, Kalamazoo, Minneapolis, Oakland, Pasadena, San Diego, San Jose, Santa Barbara, Seattle and Springfield (Mass.). The cities at or near the bottom were: Augusta, Birmingham, Charleston (S. C.), Chester, Columbus (Ga.), East St. Louis, High Point, Lewiston, Manchester, Meridian, Mobile, Rome, Tucson and Woonsocket.

I have also for each city a score, P, for the personal qualities of its population, which is a weighted average of the eleven items listed below. The fourteen cities high in G were on the average very high in P also; and the fourteen low in G were on the average very low in P.

Per capita number of graduates from public high high schools in 1934; Percentage which public expenditures for the maintenance of libraries was of the total public expenditures; Percentage of illiteracy (reversed); Percentage of illiteracy among those aged 15–24 (reversed); Per capita circulation of public libraries; Per capita number of homes owned; Per capita number of physicians, nurses and teachers minus male domestic servants; Per capita number of telephones; Number of male dentists divided by number of male lawyers; Per capita number of deaths from syphilis (reversed); Per capita number of deaths from homicide (reversed).

I make the comparison by two methods. By the first method each city is given equal weight with every other; by the second, any one day's issue of any newspaper is given equal weight with any other. The figures are always for percentages of space given to the topic in question. Each percentage has as its base the total space given to all the topics of our list.

Table I relates how the press of the cities ranking high in G and P (the scores for general welfare and for qualities of intelligence, morality, etc.) divided the space which it accorded to the 23 items; and similarly for the press of the cities ranking low in G and P.

The greatest difference was in the case of intelligence tests, to which the press in superior cities gave over three times

as large a fraction of the space. The next greatest difference was in the stock-exchange reports, which had two and a half times as large a fraction of the space in the superior cities. The next concerned radio programs. The next two concerned local crime and the game of bridge to which the press in high cities gave less than two thirds as much of the total allotment as the press in low cities did.[2] General crime comes next.

The newspapers in the cities low in G and P furnish less information and more sheer entertainment, the percentage for stories, story-pictures and comic strips combined being almost 26 for them and under 20 for the high cities.

due largely to scientific treatment of water, milk, etc., is about twice as great in the low fourteen, but the per cent. of space given to facts of science is almost the same. The per capita circulation of public-library books is only one third as great in the low cities as in the high, and the per cent. of 16- or 17-year-olds attending public schools is about half as great. But the per cent. of space given education, art and music is about the same, the newspapers of the low cities giving in fact somewhat more space. There are only one fourth as many radio sets per thousand population, but radio programs occupy over half as large a fraction of the space.

TABLE I

COMPARISON OF 14 CITIES VERY HIGH IN G (GENERAL GOODNESS OF LIFE FOR GOOD PEOPLE) AND P (PERSONAL QUALITIES OF THE POPULATION) IN RESPECT OF THE PERCENTAGE OF NON-ADVERTISING SPACE USED FOR VARIOUS TOPICS

Topic	Average percentages and ratios					
	Weighting each city as 1			Weighting each issue as 1		
	A Cities high in G and P	B Cities low in G and P	A/B Ratio	A Cities high in G and P	B Cities low in G and P	A/B Ratio
1. Foreign news: war	5.4	6.1	.89	4.3	5.6	.76
2. Foreign news: not war	2.8	3.6	.79	2.4	3.4	.70
3. Education, art and music: not local	0.96	1.22	.78	.76	1.23	.62
4. Education, art and music: local	1.85	1.47	1.26	1.60	1.60	1.00
5. Crime: not local	1.46	1.99	.73	1.33	2.03	.66
6. Crime: local	1.19	1.88	.63	1.21	1.85	.65
7. Local society, clubs, organizations	6.9	5.3	1.30	6.6	5.5	1.21
8. Local personal items	4.9	5.2	.94	4.7	5.2	.89
9. Athletic sports and games	27.5	26.5	1.04	30.4	27.9	1.09
10. Radio programs	4.4	2.4	1.84	4.4	2.4	1.83
11. Science	0.37	0.34	1.11	0.40	0.40	1.00
12. Intelligence Tests	0.18	0.03	6.23	0.07	0.03	2.33
13. Contract bridge lessons, problems, etc.	0.46	0.60	.77	0.37	0.75	.49
14. Cross-word puzzles	1.68	2.26	.74	1.52	2.19	.69
15. Questions and answers	2.38	2.33	1.02	2.01	2.44	.82
16. Stories	4.0	6.0	.66	4.0	5.9	.68
17. Story-pictures	5.2	6.6	.78	4.5	6.3	.71
18. Comic strips	10.9	13.4	.81	10.4	13.1	.79
19. Cartoons	5.0	4.7	1.06	4.3	4.5	.94
20. Weather	1.52	0.93	1.64	0.94	0.81	1.16
21. Stock and bond markets	8.5	3.6	2.37	10.3	3.9	2.67
22. Commodity markets	3.2	2.8	1.15	3.6	3.1	1.16

On the whole the differences between the high and the low cities are of the character that would be expected *a priori*, but are very small. The number of deaths from homicide per thousand population in the low fourteen is about five times as great as that in the high fourteen, but the per cent. of space given to crime news is only $1\frac{1}{2}$ times as great. The infant death rate, decreases in which are

[2] High and low mean, of course, high in G and P and low in G and P.

The press in the low cities does not emphasize local society and personal items at the expense of foreign non-war news. It is extremely unlikely that the general news not included under our rubrics, and the editorials and other comments on the news, would show greater differences in content than our counts show. They probably would show smaller differences.

It is possible that the detailed quality of the contents of the newspapers would

have shown greater differences than our counts showed. The newspapers of the superior cities may be more truthful, intellectual, moral, humane, refined and impartial than the others to a degree not shown by the counts of subject-matter. Such a qualitative analysis requires much time from very able critics and was impossible within my resources. But such casual inspection as I could make leads me to expect that these differences also are rather small. There certainly were many editorials in the press of the low cities which were excellent in every way. It must also be kept in mind that much of the contents of the press in all these cities is bought from agencies and used as bought.

The variations among cities in the contents and style of the press are very great, but they seem to be caused largely by local customs and the ideas of owners and editors, rather than by fundamental differences in the ideals of the residents. The press of a city is in fact not an accurate indicator of its general degree of civilization, welfare, humaneness or intelligence. There is a correlation, but it is not close. One glance at the infant death rate, the percentage of 16- and 17-year-olds in school, the per capita circulation of public-libraries, and the number of telephones per thousand population will give a truer picture of the quality of life in a community than a perusal of ten thousand columns of its newspapers. A newspaper is not a mirror reflecting the nature of the community where it is published. Nothing short of a solid body of facts can do that. On the contrary, the newspaper in any of these twenty-eight cities could probably change its content to be more like the average newspaper without losing much circulation or causing much criticism or even having the changes noticed, if it made them slowly enough. Indeed, a sordid commercialism could find moderate support for its kind of newspaper in our "best" cities; a competent idealism could find support for its kind of newspaper in our "worst" cities. The profiteer and the enthusiast would probably fill their papers with much the same content—namely, that which the buyers of newspapers expect to find in newspapers. In judging a community, its newspaper should be considered, but only as one among scores of features of its life.

It is common to speak of the newspapers of to-day as purely commercial enterprises managed with an eye single to profits, which are to be got from advertising, which is to be got by circulation, which is to be got by entertainment for the masses, which is to be got by avoiding all intellectual difficulties and appealing to common passions and prejudices. The facts of the counts suggest that for most of the press of the United States, this is a slander. It would be truer to say that the newspaper of today, with considerable disregard of the cravings of the populace, provides a conventional mixture of facts about what has happened during the past twenty-four hours at home and abroad, descriptions of athletic contests, statistics about prices, fiction and humor in words and pictures, and notes about women's styles, housekeeping, politics, personal health and happiness, and occasionally about the impersonal world of truth and beauty. The departures from this conventional mixture either upward toward what the ablest and best would choose in their noblest moments or downward toward what the dull and vulgar seek as entertainment, are few and slight.

Apparently those who buy newspapers still in large measure buy them not as a means of entertainment in competition with the movies, the radio, gambling, eating, drinking, sex-indulgence, etc., but mainly for the conventional features of a newspaper of the past half century. Those who make newspapers apparently still in large measure consider their craft to be that of getting and presenting news, and not an apprenticeship for pictorial magazines, Hollywood or television.

SYNTHETIC RUBBER

By Dr. B. S. GARVEY, JR.

THE B. F. GOODRICH COMPANY, AKRON, OHIO

Introduction

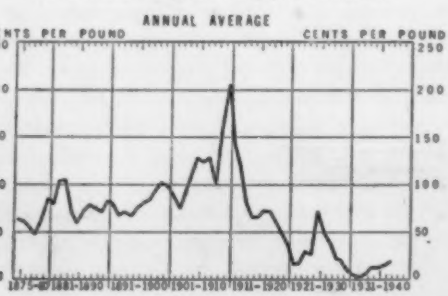
No material has ever been synthesized which is identical with natural rubber in the same sense that synthetic indigo is identical with natural indigo. The early experiments were attempts to make such a duplicate of natural rubber, and for nearly fifty years this synthesis has been one of the aims of organic chemists. What we call synthetic rubbers are materials which resemble rubber in physical properties but which differ by varying degrees in chemical composition. The development of these materials has been influenced by the supply and price of crude rubber, by political conditions and by increasing knowledge of rubber and other high molecular materials.

World production and United States prices of crude rubber since 1880 are shown in the following two charts taken from "Rubber Statistics," published by the U. S. Department of Commerce in 1938.

"Popularity of the bicycle and the demand for rubber tires brought about the high prices in the 1890's; and, similarly, the automobile and the Brazilian scheme for the valorization of rubber were directly responsible for the high prices of 1905 to 1910." These high prices caused a ruthless exploitation of all sources of wild rubber, especially in Africa and Brazil, and led to an increasing use of reclaim, although it is inferior to crude rubber. A few years after Tilden first polymerized isoprene, in 1891, the boom in rubber prices changed the primary objective of research from one of scientific duplication to one of commercial production of a technical equivalent. At the same time the infant plantation industry of the Far East was greatly stimulated. By 1917 there was an adequate supply of cheap, high-grade plantation rubber. For several years after this there was little interest in synthetic rubber.

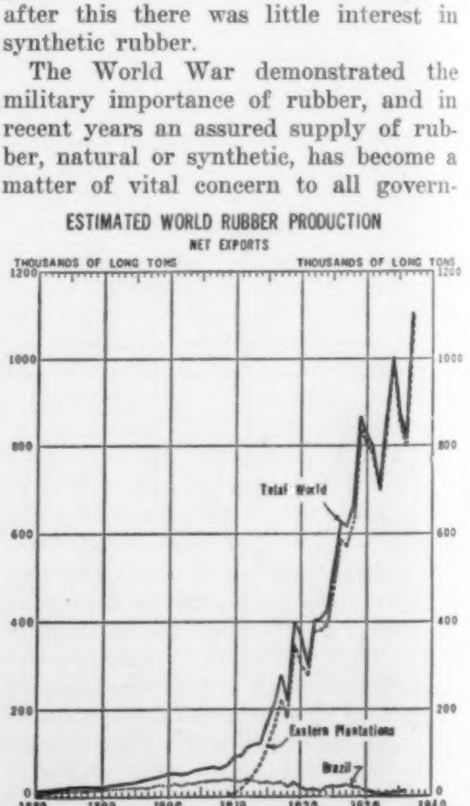
The World War demonstrated the military importance of rubber, and in recent years an assured supply of rubber, natural or synthetic, has become a matter of vital concern to all govern-

U. S. CRUDE RUBBER MARKET PRICES



ESTIMATED WORLD RUBBER PRODUCTION

NET EXPORTS



ments. For countries which are subject to blockade, like Germany and Russia, this has meant intensive, subsidized work on a synthetic replacement for natural rubber.

The accumulation of knowledge concerning polymers and polymerization has resulted in the production of two types of rubber-like materials which can compete with rubber in a free market because, in addition to the desired physical characteristics of the natural product, they have advantages which justify a higher cost.

The synthetic rubbers, Neoprene and Perbunan (Buna N), are diene polymers which yield compositions more resistant to oil and to aging under severe conditions than does natural rubber. Materials like Thiokol, Koroseal and Vistanex are flexible and elastic, although in chemical composition they are fundamentally different from natural rubber.

The Duplication of Natural Rubber

As far back as 1826 Faraday showed that the chemical composition of rubber can be expressed by the formula C_5H_8. In 1860 Williams obtained isoprene, $CH_2=\overset{CH_3}{\overset{|}{C}}-CH=CH_2$, by the destructive distillation of rubber, and in 1891 Tilden showed that it would polymerize on standing to a rubber-like product. Later investigators have demonstrated that the rubber hydrocarbon is a polymer[1] containing at least eight and probably several hundred C_5H_8 groups arranged end-to-end in the general structure $(-CH_2-\overset{CH_3}{\overset{|}{C}}=CH-CH_2-)x$.

For a number of years investigators of many nations sought methods of making isoprene and methods of polymerizing it to rubber. The most satisfactory preparations were by the destructive distillation of rubber and the thermal cracking of terpenes. Isoprene so prepared would polymerize on long standing at room temperature. The polymerization could be hastened by heating, exposure to light or by the use of catalysts such as the peroxides or metallic sodium. The products of such polymerizations were not of industrial significance because of the cost of isoprene. Furthermore, they differed chemically from natural rubber, did not process well, gave vulcanizates of poor physical quality,[2] and were not technically equivalent to it. Their behavior on aging was bad both before and after vulcanization.

When one considers the complexity of the problem it is not surprising that the aim of the first era was not reached at that time, nor has it yet been realized. In the first place, natural rubber, in addition to the rubber hydrocarbon, contains 5 to 10 per cent. of non-rubber constituents. Among these we now know are substances with profound effect on the aging and vulcanizing characteristics of the rubber. The hydrocarbon itself appears to be a high polymer of the composition $(-CH_2-\overset{CH_3}{\overset{|}{C}}=CHCH_2-)x$ in which the methyl groups are symmetrically placed along the chains and in which the geometrical configuration at each double bond is the same (it is geometrically homogeneous). With regard to double bonds, isoprene

[1] A polymer is a large molecule made by the combination of many small ones. If we consider a dish of ordinary paper clips as molecules of isoprene, we can string them all together as a chain which would correspond to a rubber molecule. Forming the chain is roughly analogous to polymerization and the chain to a polymer.

[2] Crude rubber is tough, thermoplastic, and hardens at about 0° C. When masticated on a rubber mill it becomes soft, plastic, tacky or sticky, soluble and easy to process. Vulcanized rubber is non-thermoplastic, very tough and strong, non-tacky and insoluble. It is elastic from −50° C. to well above 100° C.

$$\underset{1}{CH_2}=\underset{2}{\overset{CH_3}{\overset{|}{C}}}-\underset{3}{CH}=\underset{4}{CH_2}$$

can polymerize in four ways: 1–4, 1–2, 3–4, and 1–2 and 3–4. Along the chain it may polymerize head to head or head to tail

$$(-\underset{1}{CH_2}-\underset{2}{\overset{CH_3}{\overset{|}{C}}}=\underset{3}{CH}\underset{4}{CH_2}\underset{1}{CH_2}\underset{2}{\overset{CH_3}{\overset{|}{C}}}=\underset{3}{CH}\underset{4}{CH_2}-)$$

or

$$(-\underset{1}{CH_2}\underset{2}{\overset{CH_3}{\overset{|}{C}}}=\underset{3}{CH}\underset{4}{CH_2}\underset{4}{CH_2}\underset{3}{CH}=\underset{2}{\overset{CH_3}{\overset{|}{C}}}\underset{1}{CH_2}-).$$

If both 1–2 and 3–4 polymerizations take place, the chain may become branched or cross links may be formed between chains. Even if the polymerization be all 1–4 and head to tail, the individual double bonds may have either a cis- or a trans configuration. The polymerization must be further controlled so that the molecular weight falls in the right range. Finally suitable chemicals must be added to act as preservatives and vulcanizing aids.

The Production of a Replacement for Natural Rubber

The second phase of the work was concerned largely with the investigation of 1–3 dienes, which might be prepared economically and which would polymerize to give useful products. A measure of success along this line made necessary the use of accelerators and age resistors, a development which subsequently became of prime importance in the use of natural rubber.

The two dienes with best commercial prospects were found to be butadiene 1–3 and 2–3 dimethyl butadiene 1–3. The former could be obtained by the dehydration of 1–3 butylene glycol, and in small yields by the cracking of hydrocarbon oils. In no case, however, was low production cost realized. Dimethyl butadiene was made by the dehydration of pinacol which, in turn, was made from acetone. Processes and yields were fairly satisfactory, but the cost was high.

The synthetic rubbers made by the polymerization of these dienes were of poor quality and were more nearly comparable to reclaims than to crude natural rubber. As a result they had no large-scale development prior to the World War. Under pressure from the British blockade the Germans were forced to extraordinary efforts and put into production the synthesis of dimethyl butadiene and its polymerization. Several hundred tons of methyl rubber were made. In addition to the poor qualities it shares with the butadiene polymers, this rubber has the added disadvantage of becoming hard and of taking a high set in ordinary cold weather. Hence it was often necessary to jack up the wheels when trucks were left standing outdoors in cold weather.

After the war the large supply of cheap, high-grade, plantation rubber discouraged the development of the synthetic material, especially because of the poor quality of the latter. There was very little development in this field over the next decade.

Some time in the later nineteen twenties, the synthetic rubber problem was reopened, this time by two of the world's largest chemical companies, the I.G. in Germany and du Pont in America. The German work has resulted in the Buna rubbers and the American work in Neoprene.

In Germany the first step was a review of the various butadienes to select the most satisfactory one from the standpoint of quality of the polymer, availability of raw materials and economy of manufacture. Butadiene was selected. The starting material is coal, which is heated with limestone to make calcium carbide. With water this gives acetylene, and this in turn adds a molecule of water to give acetaldehyde. The aldehyde is condensed to aldol. These three

reactions are old and had been well developed. The aldol is then catalytically hydrogenated to 1–3 butylene glycol and this is catalytically dehydrated to butadiene. While there are a number of steps in this reaction, the over-all yield is good and the raw materials are available in Germany. In a modification of this procedure ethyl alcohol, from any source, is dehydrogenated to acetaldehyde. The aldehyde is converted to aldol, which is hydrogenated with the hydrogen removal from the alcohol. In the United States the most economical source of butadiene is petroleum or natural gas, from which it can be made by cracking or dehydrogenation processes.

The first products of the I.G. were made by polymerizing liquid *bu*tadiene with sodium (*Na*). Hence the name Buna. Like the pre-war products, these were of poor quality. In an effort to improve the quality of the rubber, the polymerization of butadiene was performed in aqueous emulsion. It was soon found that the addition to the butadiene of other polymerizable materials modified the polymerization and greatly improved the quality of the product. As a result of this work there are at present two principal types of Buna. Buna S is a mixed polymer of butadiene and styrene, while Buna N, or Perbunan, is a mixed polymer of butadiene and acrylic nitrile. Both are made by controlled polymerization in emulsion.

Buna S is considered primarily as a substitute for natural rubber in tires, belts, etc. It is more difficult to process than natural rubber, but with suitable precautions can be handled on essentially the same machinery. It has little "tack," the quality of natural rubber which makes two pieces coalesce when pressed together. This makes building operations difficult. The vulcanizates, however, are of a quality comparable with natural rubber. For tire treads Buna S is as good as, or better than, natural rubber. For pure gum compounds, such as rubber bands, it is much worse. The difference is due to the great reinforcing action of carbon black on Buna. Buna S is cheaper than Buna N because styrene is cheaper than acrylonitrile. Hence Buna S was selected for large-scale production in Germany.

The Development of Improvements on Natural Rubber

With Buna N and Neoprene we come to the third phase of synthetic rubber development. Buna N, like Buna S, can with certain limitations be used as a substitute for natural rubber. In addition it has certain great advantages. It is but little affected by petroleum hydrocarbons and is much more resistant to heat than natural rubber. Consequently, it can be used satisfactorily under hot and oily conditions where rubber fails quickly. It has even better abrasion resistance than natural rubber. Like Buna S, it is difficult to process and lacks adequate building tack. However, it can be handled satisfactorily in factory operations.

The du Pont development started from the work of Nieuwland at Notre Dame on acetylene and led to the production of substituted butadienes. Two molecules of acetylene polymerize to form vinyl acetylene, which adds one molecule of hydrogen chloride to form chloroprene, $CH_2{=}\overset{\overset{\displaystyle Cl}{|}}{C}{-}CH{=}CH_2$, a diolefine in which a chlorine replaces the methyl group in isoprene. While other substituted butadienes have been made and polymerized, chloroprene is the only one which has achieved commercial significance.

Under properly controlled conditions liquid chloroprene polymerizes to a rubbery polymer, similar to natural rubber and of use as a replacement for it in most cases. Like Buna N, it has impor-

tant advantages over natural rubber. It is resistant to the action of petroleum hydrocarbons and vegetable and animal oils. It is not sensitive to sunlight or corona discharge, and it will not continue to burn when ignited. Hence Neoprene can be used in many places where natural rubber can not. Unlike natural rubber or the Bunas, Neoprene is not vulcanized by sulfur, and hence a new technique of compounding had to be developed. Although special precautions are also necessary, it can be used in regular factory operations.

More recently the process for polymerizing chloroprene in emulsified form has been worked out. This permits smoother and more efficient production with resulting lower prices.

Russian Developments

Because of political and economic isolation, Russia was the first of the great nations to attempt autarchy; and because rubber is one of the few essential raw materials not available in Russia, a great deal of work was done on synthetic rubber, as well as on the cultivation of rubber-bearing shrubs similar to Guayule. It is known that in Russia butadiene is produced both from alcohol and from petroleum. Apparently this is converted principally to the sodium polymer. It seems probable that rubbers of the Buna type are also being made. It has also been reported that chloroprene is being polymerized to a material similar to Neoprene. Outside of Russia, however, little is definitely known about these Russian products.

Other Elastic Materials

There are several materials of fundamentally different chemical constitution which are sufficiently like rubber in physical properties to justify their inclusion in a discussion of synthetic rubber. All the previously discussed materials have been polymers or co-polymers of butadiene or substituted butadienes. Thiokol, Koroseal and Vistanex are elastic products derived from other basic molecules.

Thiokol. When ethylene dichloride is refluxed with an aqueous solution of sodium polysulfide a linear polymer is formed which is rubbery and which has the constitution

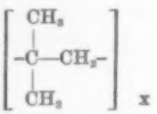
$$(-CH_2CH_2-S_x-CH_2-CH_2S_x-)y.$$

In place of ethylene dichloride, propylene dichloride, dichloroethyl ether or other dichlorides may be used. These materials were developed in America as Thiokol and in Germany as Perduren. They undergo a type of vulcanization, but the effect is not as pronounced as with rubber. Thiokol has a characteristic odor. With respect to tensile strength, toughness and cold flow it is not as good as the materials previously discussed, but it probably has better general solvent resistance. It was the first material of this group to be developed commercially.

Koroseal. The gamma polymer of vinyl chloride is extremely tough and is unique in the strength and toughness of the gels formed from it with various liquids. As Koroseal in this country and Igelite in Germany, these gels have become of great commercial importance. The polyvinyl chloride itself is resistant to nearly all chemicals and to most solvents. It does not burn or support combustion, and is practically unaffected by aging. By skilful compounding of plasticizers, pigments, etc., flexible and elastic gels can be obtained which retain, in large measure, these resistant characteristics. Koroseal need not be vulcanized. It can be tubed, calendered and molded thermoplastically. In addition to the rubbery types which are used for wire insulation, tank linings, special hose and tubing and molded parts, Koroseal can be made as a hard molding plastic, as transparent films for packaging, and as

a waterproof, greaseproof and age-resistant coating for all kinds of fabrics.

Vistanex. Vistanex is polymerized isobutylene of the probable structure



It combines to a considerable extent the physical properties of rubber and the chemical properties of paraffin. Like rubber it is a hydrocarbon, but unlike rubber it has no double bonds and therefore does not vulcanize. On a mill it does not become as plastic as rubber and it is therefore more difficult to process. Cold flow limits its use as a rubber substitute and it is used principally as a coating material. The lower polymers are extensively used in lubricating oils to reduce the fall in viscosity with rising temperature.

Recent Developments

During the year which has elapsed since the outbreak of the war in Europe there have been several announcements which show that extensive research programs have been under way for several years on the development of new synthetic rubbers. All the products recently announced use petroleum as the basic raw material and all appear to be some type of butadiene copolymer. Definite compositions have not been announced.

Buna. The Standard Oil Company of New Jersey has acquired the American patent rights relating to the manufacture of the Buna rubbers and has announced that it will start production of Perbunan late in 1940. The Firestone Tire and Rubber Company has taken a license under these patents and has announced plans for starting production.

Butyl Rubber. The Standard Oil Company has announced the small-scale production of "Butyl Rubber," which is a copolymer of olefins and diolefins. The proportion of diolefin is small so that the vulcanized product is essentially a saturated hydrocarbon. While no definite composition of the material has been reported, the description of its properties suggests that it is a Vistanex type made vulcanizable by the use of a small proportion of a diolefine. The high proportion of olefine in this rubber makes it different from the others. It is too early to do more than guess as to its place in the general picture.

Ameripol and Hycar. The Hydrocarbon Chemical and Rubber Company has announced the small-scale production of "Hycar O R" and is enlarging its plant for the manufacture of this material. There are two types of Hycar, one of which is oil resistant and other not. Both are butadiene copolymers of undisclosed composition. The B. F. Goodrich Company markets products made from Hycar under the general trade name, "Ameripol."

Ameripol tires made of Hycar are being sold to the public at a premium of about 30 per cent. above the cost of tires made of natural rubber. Experience indicates that these tires are equivalent in quality to the present tires of natural rubber. There are a number of minor differences in the production of tires when Hycar is used. Through continuous small-scale production the B. F. Goodrich Company hopes to solve the more outstanding problems before the need for large-scale production may arise.

The oil-resistant type of Hycar is being used extensively in such mechanical goods as hose, gaskets and articles for the printing and automotive industries. The service given by the finished articles has proved to be very satisfactory.

The Hydrocarbon Chemical and Rubber Company has been formed by the B.

F. Goodrich Company and the Phillips Petroleum Company to integrate the production and sale of the crude synthetic rubber which is being offered on the market as Hycar.

Chemigum. The Goodyear Tire and Rubber Company has announced the small-scale production of "Chemigum" and is expanding its production. It is a butadiene copolymer of undisclosed composition which is resistant to oil.

The company is using "Chemigum" in regular production in various types of mechanical goods where oil resistance is important. It is proving satisfactory in such service. Experimental tires have been made and have given good service in tests.

Synthetic Rubbber in the United States

As a national problem for the United States the synthetic rubber problem should be considered from two technical angles: (1) as a replacement for natural rubber, and (2) as an improvement over natural rubber; and from two economic angles: (1) under normal economic conditions, and (2) under emergency conditions. The views expressed here are the personal views of the author.

As improvements on natural rubber, Neoprene, Buna N, Hycar and Chemigum have already established positions in the American rubber industry because the superior properties which can be obtained with them are worth more than the added cost as compared with natural rubber. The production of Neoprene is now on a large scale ($\frac{1}{2}$ to 1 million pounds per month), although even this comprises less than one per cent. of the total rubber used. Substantial production of Buna N by the Standard Oil Company, of Hycar by Hydrocarbon Chemical and Rubber Company, and of Chemigum by the Goodyear Company is expected before the end of 1940. While in one sense these materials compete with natural rubber, they also tend to expand its use because they are often used with it in composite structures where rubber alone would be unsatisfactory.

The use of these materials is based chiefly on their resistance to oils, oxidation and sunlight. Butyl rubber is reported not to be resistant to oils but to have other properties which should lead to considerable use. With increasing knowledge other types of synthetic rubber may be expected with other special properties. There should be continued expansion of the use of these special synthetic rubbers regardless of the price of natural rubber.

Koroseal, Thiokol and Vistanex have also shown their worth under normal economic conditions. Thiokol is used principally for solvent resistant hose, packing, etc. Except for wire and cable covering, the uses of Koroseal and Vistanex are principally in fields where rubber has never been used to any great extent. Technically these materials might be substituted for rubber in a considerable volume of production, but ordinarily such a substitution would not be profitable.

The position of a synthetic replacement for natural rubber will depend on its relative cost and quality. Crude rubber is a high-quality product with excellent characteristics for factory processing. So far none of the synthetics has proved much better for any of the large volume uses. Hence, unless new advantages are discovered, the competition will be on a cost basis. This type of rubber will probably be either a polymer of a copolymer of butadiene. Its cost will depend considerably on the volume of production. For at least the next decade in this country petroleum appears to offer the most economical source of butadiene.

Rubber is one of the most important raw materials obtained almost exclusively outside of the United States, and

the continuation of an adequate supply is a vital part of any program of national defense. Even by the end of 1940 the total production of all the materials discussed here will probably not exceed 5 per cent. of the rubber requirements of the country. To satisfy this demand there will be required an industry with a capacity at least twenty times that of the present production of synthetic rubber, almost ten times that of the present dye industry and three to five times that of the present synthetic resin industry. Such production is not built up overnight, even under emergency conditions.

If shipments of rubber should be stopped, present supplies could be extended to meet requirements for about a year by expanding the production and use of reclaim and synthetics already in production. Plant construction and operation would be greatly aided by the knowledge already available from the production of various types of synthetic rubber. Even so, it would probably take two or three years to raise production to an adequate level. Such expansion is not normally practical and will require government support as a defense measure.

The National Defense Advisory Committee, in considering what might be done to replace rubber should its importation be prevented, is studying the problem of quantity production of synthetic rubber in this country. It seems advisable that definite plans should be made promptly so that the manufacture of synthetic rubber in substantial quantities can be started as soon as possible. Experience in its manufacture and utilization for the more essential rubber products will give assurance of the ability of the nation to replace natural rubber without delay should the necessity arise.

SCIENCE AND DEMOCRACY

One of the only two articles that remain in my creed of life is that the future of our civilization depends upon the widening spread and deepening hold of the scientific habit of mind; and that the problem of problems in our education is therefore to discover how to mature and make effective this scientific habit. Mankind so far has been ruled by things and by words, not by thought, for till the last few moments of history, humanity has not been in possession of the conditions of secure and effective thinking. Without ignoring in the least the consolation that has come to men from their literary education, I would even go so far as to say that only the gradual replacing of a literary by a scientific education can assure to man the progressive amelioration of his lot.

Scientific method is not just a method which it has been found profitable to pursue in this or that abstruse subject for purely technical reasons. It represents the only method of thinking that has proved fruitful in any subject—that is what we mean when we call it scientific. It is not a peculiar development of thinking for highly specialized ends; it is thinking so far as thought has become conscious of its proper ends and of the equipment indispensable for success in their pursuit.

If ever we are to be governed by intelligence, not by things and by words, science must have something to say about what we do, and not merely about how we may do it most easily and economically. And if this consummation is achieved, the transformation must occur through education, by bringing home to man's habitual inclination and attitude the significance of genuine knowledge and the full import of the conditions requisite for its attainment.—*John Dewey, in "The Scientific Method and Study of Processes."*

HEREDITY AND THE PHYSICIAN

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THE belief by the physician that an intimate knowledge of the constitutional background of his patient is of distinct value to him has undergone changes in the past century. At a time when the "family physician" was indeed one who ministered to the whole family, who knew and treated the brothers and sisters of his patient, the uncles and aunts and the cousins, such a close understanding of the family fiber was to the physician a sixth sense. It supplemented what he heard, saw and felt in his patients, and taught him often to know what to expect and how they would react to his treatment. Thus he knew that Mrs. H. would probably be an invalid for weeks after her children were born, while Mrs. M. would be up and around within a week. He had learned that the N children ran a very high fever without much serious trouble, and that the T children were likely to have convulsions during relatively minor illnesses. When Mr. S. would come hurrying in to say that little Amelia, who was bright and well yesterday, was crying fitfully and running a fever, his first thought was, "Another running ear: whenever any of those children get a cold, they always have running ears." Or when Mrs. Z. came to him in her first pregnancy, he was more than watchful, for he had seen kidney complications in her grandmother, her mother and her older sister. He had seen little Tommy P. die of hemorrhage after he lost his first tooth, and he felt helpless when Tommy's little brother began to bleed from a scratch on the forehead, although he applied all the treatments recognized by the profession of his time. He knew that some of his patients would weather most illnesses and live to be old men and women, while others would fade quietly away from conditions not half so severe. Not always were his predictions correct, but the knowledge of the background of his patient helped him again and again, and his recognition of the constitution of the sufferer was often as important in his diagnosis, prognosis and treatment of the case as were the facts which he obtained through observation with his keen eyes, or through the tips of his sensitive fingers.

INFLUENCE OF BACTERIOLOGY UPON IMPORTANCE OF HEREDITY

And then a new order came to replace the old. Science taught that many of the diseases which he treated were due to infinitely small forms of life, entering the body of the patient perhaps through the nose or the lungs, where they grew into millions of other small forms of life, and thus caused the illness. The vogue of bacteriology with its precision in isolating the germ, and in finding that the same germ always caused the same disease, left well in the background the idea that the constitution of the patient was of great importance. If you developed tuberculosis when your mother had died of it, it was not because you had inherited the weak lungs of your maternal parent, but because you had been exposed to the tubercle bacillus that had killed her, and so you succumbed. Locomotor ataxia in father and son did not arise because they were related, but because both were exposed to the spirochaete of syphilis. Disease after disease was shown to be caused by bacteria, para-

sites, viruses, until it seemed that the constitutional background of the patient had little to do with his getting sick, and that the environment was responsible for all his ills.

As industry expanded, new chemicals brought new hazards; and more illnesses, formerly thought to run in families, were found to be dependent upon the similarity of occupation of various members of the family group. Also as industry grew and as transportation facilities increased, sons and daughters left the villages where they were born, and migrated to cities or to new lands. There they came into the hands of physicians who did not know them or their forebears; who treated them as individual patients and not as members of a family with certain traits. Migrations also made members of families lose contact with one another, so that a son in one part of the country or in a distant land did not know what his grandmother died of or what had been the character of the illness which took off his father in his early fifties. In this way, because the patient knew less of his family, he was able to give less and less information to the doctor; who in turn, because he got less and less information about the family from his patient, grew more and more cursory in the examination into the history of his patients' families, until finally we have the medical profession sinking to the level of writing on a history sheet, "Family history negative." As if the family history of a patient ever could be negative! None of his relatives may ever have had the same illness from which the patient suffered, but he had a father and mother; they were either alive or dead; if alive, they had reached a definite age and were either well or ill. If ill, they were ill of some disease; if dead, they died at a certain age and of some cause. The patient was either the only child in the family or there were others; if there were others, they were either younger or older, were male or female, were alive and well or ill; or had died of some cause at some age. There can be no such thing as a "negative family history," and the physician or the medical student or interne who writes that down acknowledges thereby that either he has been too lazy to inquire for the facts or too indifferent to write down the facts which he elicited.

True, it is not always necessary on a history sheet to write down a long discourse on the family of the patient. If a man comes in with a broken leg, acquired from having fallen from a truck, it probably does not contribute either to the diagnosis, the prognosis or the treatment to know of what his grandparents died or whether he has brothers and sisters. But if the patient states that his leg snapped when he was rising from his chair, a family history is of interest and importance. In other words, when the disease with which one deals is of *obvious* external origin, family history is not so essential, although it should be taken with care; but when the disease with which one is dealing is of constitutional origin, a family history may be of great significance and should be taken most carefully.

Discovery of the Laws of Heredity

Oddly enough not only did bacteriology and scattering of family groups play a part in lessening the emphasis on the value of heredity to the physician, but the discovery of Mendel's work and the keen awakening of the scientific world to the laws of inheritance discouraged acceptance of evidences of heredity in man. The use of forms like Drosophila in which a whole lifetime is telescoped into a few days, in which innumerable generations can be bred in the working lifetime of a scientist; or the use even of mammals like mice which may produce four generations to a year, instead of four to a century, so impressed every one

with the value of the experimental method in genetics that those unable to use such a method on human material, and able to observe at the most only three generations, perhaps not more than two, came to believe that what little they could observe in man was worthless. This attitude was to a large extent fostered by some geneticists who felt that unless the matings could be experimentally controlled observations were useless. Of course such an attitude was wrong. The observer of human material is handicapped to a tremendous degree, because he can not make experimental matings, nor do his subjects reproduce in large enough numbers for the data to be significant, nor can he examine the germ cells for cytological evidence of disturbances in the chromosomes. But all this does not preclude his making careful observations of matings that do occur, and of applying other methods than those of the experimentalist to his observations. Even the experimental geneticist often can not tell the hybrid form from the homozygous dominant until he breeds it to the homozygous recessive and finds that he has offspring of two kinds. If he mates two hybrids, he often can not tell which of the animals exhibiting the dominant trait is homozygous for it and which is hybrid. He must breed them to find out; and so it is with man. Observations on the results of human matings may be of as much value in some instances as are those on the progeny of controlled experimental matings; the difficulty is that they are so few in number and one has to wait for such matings to occur spontaneously.

The explanations which the observer of human heredity makes of his observations must of course rest upon facts which the experimentalist elicits from his controlled matings. He can test his data by the experimentalists' criteria, and arrive at conclusions that are worth while. After all, it is not of much value to the physician to find that a certain malformation is due to a deletion instead of a translocation of a specific chromosome in his patient. What is of infinitely more value to him is that if his patient has produced a child with a certain type of malformation, she may produce another such child, and that the chances of duplication of the deformity in later offspring are fairly large for some deformities and negligible for others. Even when he knows that the chances are one in two that a son of a carrier mother will develop hemophilia, he can not predict that the next child will be a son or, if it is, that it will inevitably inherit the gene for hemophilia. Nor can the scientist with his controlled matings under similar circumstances predict what percentage of the next litter of mice or of the next batch of flies will show a certain trait. Both can predict averages on the basis of laws of probabilities, but neither can predict accurately the specific traits which each offspring will show when his parents are not homozygous.

Reawakening of Interest in Medical Genetics

The pendulum is now beginning to swing back again to a belief that inheritance plays a large role in disease, and that the physician who knows the fundamentals of the laws of heredity and who knows the family background of his patient is better equipped to diagnose, treat and give a prognosis intelligently than is the man who lacks such knowledge. It is being recognized that, although bacteria cause disease, susceptibility and immunity to these bacteria are hereditary. Webster has shown with his mice that epidemics introduced at will into his colonies rage with violence or die out, depending upon the relative proportions of hereditarily highly susceptible or highly immune animals which he has placed in the population.

It has been shown that although the

physician lacks the experimental method in studies in human heredity, observations on many cases by many workers do lead to certain general principles which he can use, both in advising his patients and in diagnosing and treating their ills. There have been several factors responsible for this rebirth of appreciation of the importance of a knowledge of heredity to the physician. One is the fact that many more of the general public are being educated in colleges and are being exposed to the teachings of biologists. Here they may learn something of the general laws of heredity, and may learn to appreciate that man is subject to them as well as are the animals and plants whose hereditary traits they see exemplified in the laboratory. Medical students also are learning a little genetics in their premedical courses. A second factor is the popularization of science by certain writers, who put into the hands of the non-medical public simplified genetic truths as discovered in the laboratory. A third factor is the leavening influence of a few ardent students of human heredity, both within and without the medical profession, who strive to have genetic truths taught to the medical students who are to be the physicians of to-morrow. They meet with the objections that there is no time in the medical curriculum for any new subjects and that "there should be a closed season for medical students," that the students can pick these things up for themselves in the clinics, etc.

As Lord Horder once remarked, there would be room in the medical curriculum, were other *less important* things discarded, to make a place for a course in inheritance in disease. The students might be spared learning the times of appearance of all the ossification centers in the bones of the body, that being better typed upon a card and hung above the desk than carried in the head to the exclusion of more important matters. The same might be said of so much anatomical detail which the student is expected to cram into his mind, and which he never uses unless he does so at the autopsy table, at which time he can look up the standard measurements and weights of organs. He might give up learning what veratrin and curare do to frog's muscles, which he will never use in his clinical work, for the sake of learning the syndromes which he will meet in his patients. He will probably never hear of many of the hereditary disorders unless he learns of them in a course in genetics. There is not much use in hoping that students will read about inheritance in disease after they leave medical school unless they are taught the rudiments of the subject in their student days. To the physician who knows something of the laws of inheritance, and what types of disease are likely to be inherited, examples of hereditary disorders are constantly manifesting themselves; to the physician who knows nothing of this fascinating subject, they are completely lost.

The following is an example. Not long ago a friend told me of an acquaintance who had suddenly developed intense swelling of the eyelids, so that she could not see. Several physicians had seen her, treated her ineffectively, and she still remained a blind prisoner in her room. I asked if she had any relatives who had had similar experiences, thinking that she was probably a sufferer from hereditary angioneurotic edema. The victim was quite surprised when questioned whether any of her family had a similar trouble and asked how I knew. In view of the fact that this disease can be so swiftly fatal if it attacks the vocal cords, or the laryngeal mucosa, it would have been desirable for the physicians in question to have attempted first to detect any external factor which might bring on the edema, and second, if there was any therapy which would

reduce the edema, to give her directions to always have it about her, and to take it at the slightest sign of the trouble. None of the physicians had recognized the true character of the edema, nor that it could affect the laryngeal mucosa as well as the eyelids.

Value to the Physician

I have said that gradually more of the medical profession are becoming aware of the value of a knowledge of inheritance as a part of their professional equipment. How valuable can it be, and is it worth while spending time on teaching medical genetics in medical schools? First, it gives the physician an acquaintance with the laws of heredity that makes him a much more intelligent reader and writer of medical reports. It saves him from making the fallacious statements on heredity which now are a commonplace in medical literature. For example, we see the statement made repeatedly in medical texts, "Disease X is hereditary in a small per cent. of the cases, familial in a much larger per cent., and sporadic in almost half the instances." The percentages differ of course for different diseases. Or we may see that "Disease Y is not hereditary, it is merely familial." Such statements would not occur, of course, if medical students were trained in genetics and knew that sometimes a disease may run directly through two or more generations (the so-called hereditary cases) or it may be transmitted as a recessive and appear in several siblings without there being any history of it in ancestors (the so-called familial cases): and finally that it may appear in only one child in a family without there being necessity of denying its hereditary nature. If the disease is transmitted as a recessive, then the majority of cases will be "sporadic," since more families are likely to have but one affected than they are to have two or more affected. This is true in all families with five or fewer children. Not until we get to families with six or more children are we likely to find the majority of families with at least two affected with a recessive trait. But as families of six or more children form less than one fourth of the population, it is quite clear that the type of case designated as "sporadic" is the predominant type. It may nevertheless be dependent upon factors resident in the germ cell, and therefore hereditary.

If the physician knew some of the fundamental genetic laws, he would not make statements such as this: "Disease X is known to be a familial disease, but the patient here described is the only one in the family affected. Therefore this child can not have disease X, although all the symptoms and findings are suggestive of that diagnosis." It would seem obvious that some child in the family has to be the first to be affected; it would be most unusual to have all the potential victims develop it simultaneously. As just stated, if the disease is transmitted according to the recessive, one child only in the family will be affected more often than will two or more.

Xeroderma pigmentosum, a cancerous degeneration of the skin, is admittedly dependent upon a recessive gene substitution, and hence hereditary; nevertheless this disease affects only one child in the family in about two-thirds of the families, and more than one child in the remaining third.

The genetically trained physician would not decide that amaurotic family idiocy was not dependent upon recessive genes in the family he described because it failed to show the 3:1 ratio expected in such cases. He might find only one out of twelve children showing the anomaly; but he would know that of all families of twelve children in which amaurotic idiocy occurs, one in every seven families will have but one of the children affected, the other eleven chil-

dren being normal. He will understand that although one fourth of a family where both parents are normal but carriers of a recessive trait will be affected on the average, not all families in actual life will have the ideal percentage of 25 showing the disease. He will not even demand that a *series* of families in which amaurotic idiocy is found should have 25 per cent. affected; he will know that if he has a series of families he will probably find considerably more than 25 per cent. with this anomaly. He will not say that polydactyly is not behaving as a dominant trait in the family he reports, merely because 4 of 6 children, instead of an expected 3, have too many fingers. These things he will know and he will be saved from making gross errors which serve to lessen his scientific reputation.

But the average physician may object that he has no intention of writing articles for journals, and if he did he would not attempt to discuss the hereditary angle of any disease. Are there, therefore, any more tangible benefits to be derived from a study of medical genetics than that of making him a more educated man, or than the mere saving of face?

Medical Genetics Helps in Diagnosis

It is quite obvious that the most important, as well as the most difficult, part of medical practice is to diagnose correctly. If one has the diagnosis, then even the less intelligent can look up in recent books on therapeutics the most approved treatment, and carry it through with a large share of success. The crucial thing is to diagnose properly. Now a knowledge of medical genetics will not enable one to diagnose all disease by any means, but it will help not infrequently if one's mind is alert to its possibilities. Let me give a few examples. These could be multiplied many times, and they have not been chosen because they are the most spectacular, but merely because they are actual instances in which a knowledge of inherited disease has helped the physician, and are instances which are known to me.

A child of ten or thereabouts developed a large bony growth on his arm. The pediatrician, suspecting a malignant growth, had an x-ray picture taken of the arm. The roentgenologist pronounced it sarcoma and advised immediate amputation at the shoulder. The parents were unwilling to have this done, but when the swelling increased in size they demanded the opinion of other physicians. The child was taken to another city, and there the surgeon who was consulted diagnosed a bony exostosis. He not only showed that there were other beginning bony excrescences on the child's skeletal system, but also that the father who had accompanied the child had bony exostoses, none of which had ever grown large enough to call his attention to them.

A man was brought to a physician with a history of repeated hemorrhages from the stomach, the last so severe as practically to exsanguinate him. The diagnosis rested between several possibilities, one being gastric ulcer. Should diet or surgery be employed? The father of the patient volunteered the information that he had suffered from profuse nosebleeds all his life. To the man unacquainted with hereditary diseases (and again let me emphasize that many of the hereditary diseases are not mentioned in the ordinary course in medicine, and hence the student is unaware of their existence), there would seem to be no connection between epistaxis in the father and gastric hemorrhage in the son. But to the genetically initiated, the possibility that the father had telangiectasis in the blood vessels of the nasal mucosa, while the son had the same anomaly in the vessels of the gastric mucosa, was very real. Exploratory operation, with the wall of the stomach il-

luminated, showed that the physician's "hunch" was correct and a large dilated thin-walled vessel which had ruptured was found and excised. The patient recovered and his gastric hemorrhages stopped.

A child of about eight, with thin, sparse hair, dry skin and a few irregular teeth, was taken to a physician for treatment. The diagnosis of myxedema was made and the child was given thyroid medication. He did not improve, but seemed definitely worse and finally refused to take any more medicine. He was then taken to another physician who had heard of hereditary ectodermal dystrophy, and who recognized that the thin, fine hair, the absent teeth, the dry skin might all be explained by the fact that in the development of this child, something had gone wrong with the derivatives of the ectoderm, so that he lacked most of his hair follicles, most of his tooth buds, and all or most of his sweat glands. Examination of others in the family showed that the mother, too, had fine sparse hair, dry skin and lacked some teeth. It was true that the correct diagnosis could not initiate an active correct treatment, but it could bring about one that was passive, which was to leave the child alone. He was already suffering from inability to regulate his body temperature through evaporation of sweat, and suffered intensely in hot weather because of that failure in his heat-regulating mechanism. The first type of treatment whipped up his metabolism to a higher rate and made him even more uncomfortable than before.

Recognition of this syndrome of ectodermal dystrophy in children may be of great therapeutic assistance when they develop childhood diseases, for they run a grave risk of dying from lethal temperatures following mild infections, because of inability to lower the temperature by evaporation and radiation. Treatment directed toward keeping the temperature within bounds may save them.

The Value of Medical Genetics in Treatment

Naturally, if diagnostic ability is improved, therapeutic measures will improve accordingly. If the bony lump is diagnosed as sarcoma, amputation is the treatment prescribed, but if an exostosis is recognized, the arm is saved. If gastric ulcer is suspected a dietary régime may be instituted, which would help the ulcer, but leave untouched the dilated blood vessel causing the trouble. If what looks like a fractured clavicle does not heal, the patient may be subjected to several operative procedures to insure union of the ends of the bone; but if the physician has recognized that the clavicle on the other side which was not broken also has ends which are not united, he recognizes his patient as an example of cranio-cleido-dysostosis and does nothing. No completely rational treatment can ever be given until the physician knows what is wrong with the patient. I recall two small boys, both of whom were diagnosed as problem children by psychologically minded physicians. The first, although six, suffered from enuresis. Despite punishment, various kinds of treatment, etc., the child continued to wet his bed. Finally he was taken to another physician, who looked at him not as a psychological but as a physical problem, and elicited from the mother the fact that the child drank huge quantities of water at all times, even during the night. Realizing that he wet the bed because he drank so much water and that he had diabetes insipidus, he diagnosed the case as the Hand-Schiller-Christian syndrome, in which xanthomatosis of the bones of the skull, exophthalmos and diabetes insipidus are present. That physician controlled the enuresis by proper medication. Up to the present, this disease has not been

included in the category of hereditary diseases, but it probably will be found to belong there. It is due to an anomaly of lipoid metabolism and as such very probably has a genetic basis.

The other little boy was considered a problem child at a very early age by an over psychologically minded pediatrician. He vomited practically everything which was given him except his mother's milk. He was looked upon as having such a strong maternal fixation that he would eat no food other than hers without vomiting it. But his father was an asthmatic, a sufferer from hay fever and strongly allergic to a number of foreign proteins; his mother was highly allergic to several plants, and her whole family for three generations were allergic to various foods, plants, dyes, etc. When he was finally recognized as a product not of psychological traumata, but of his hereditary allergies and when rational treatment of gradual immunization to egg white, to cow's milk, etc., was instituted, he ceased being a problem child.

If the physician has heard of the hereditary disorder known as periodic paralysis he may bring his patient out of an attack or may inhibit an attack by injection of potassium salts. But if the practitioner has never heard of this syndrome, he may be non-plussed or think that the patient is malingering; or he may even try to psychoanalyze him out of some subconscious complex.

The condition known as myotonia congenita or Thomsen's disease has a curious history. The man who first described it was himself its victim. It consists of difficulty in initiating or stopping voluntary motion. Thus the man who wants to shake hands with you can not raise his hand quickly enough to meet yours, but when he finally clasps your hand firmly, he continues to hold it in an ever-increasing embarrassment. The son of the doctor who first described this syndrome was being punished for malingering by the military authorities, for he could not (or would not, as the officers thought) obey an order promptly. He could not march when the order was given; then when his comrades were ten paces away, he would start up slowly at first but with ever increasing acceleration until he was marching normally. But when the order to halt came, he still went on walking for about ten paces more. The father, who had managed to keep his defect to himself, by never making any sudden move and by concentrating for some moments before he made any motion, revealed his condition in order to save the lad from punishment.

Although this condition was described many years ago, it had been forgotten, and when two brothers, both with the disease, were drafted in the German army during the War of 1914, they underwent for months much the same experiences as those just related. Finally the medical officer before whom one brother came for examination after having served kitchen duty for his supposed disobedience, recognized the disease, and the soldier was dismissed. He then managed to get his other brother out of the army also.

A patient whose brother had developed gastric carcinoma had his symptoms of digestive disturbance treated by a genetically minded practitioner with far more concern than would have been the case had there been no such family history. Twins developed breast cancer, several years apart. Later another primary cancer in the other breast developed in each twin; and finally an ovarian carcinoma occurred in the first twin. Should the ovaries of the second twin be removed as a preventive measure or should she merely be watched? If the latter course is adopted, it is safe to say that if she develops ovarian carcinoma, it will be detected at an earlier date than it would have been had there been no hereditary history of it.

Medical Genetics in the Field of Preventive Medicine

If it is easier to diagnose disease, it becomes as a matter of course easier to treat it and ultimately to prevent it.

Our eyes have been turned so constantly on the infectious diseases that we have largely forgotten that preventive medicine in the realm of inherited disease also furnishes a very large scope for our ingenuity. And so successful have we been in the realm of infectious diseases that many which formerly claimed a large percentage of the population have been completely or almost completely eliminated. With each advance in that field we will be confronted in ever greater numbers by hereditary diseases, and if we would avail ourselves of all opportunities for preventive work we must begin to bring these diseases into the orbit of our consciousness. Some hereditary diseases will be impossible of prevention, since we can not know what initiates them other than that they are dependent upon hereditary factors, but in some instances we may prevent their manifestations. Thus in periodic paralysis, we can not prevent the sufferer from inheriting a peculiar potassium metabolism, but we can prevent the symptoms from appearing by furnishing him with potassium. In pernicious anemia, we can diagnose the early stages of the disease in those who have not yet developed it, by looking for the gastric juice alterations that seem to be its forerunners. Long before the blood picture in the circulation alters, or before the hemopoietic system undergoes its primary change, and long, long before the nervous symptoms are manifested, one can detect the achylia gastrica in potential pernicious anemia patients. By proper therapy it may be possible to prevent the actual disease symptoms from appearing. Whether this will be completely and always possible we have yet to see; this form of preventive medicine is too young for us to make any pronouncement upon it.

Cardiovascular disease has long been first in the list of "causes of death." Many of these conditions are of course not hereditary; they are due to damage done to heart and vessels by some infectious condition. These are being lessened materially, and hence the cases of cardiovascular diseases that are left will become increasingly more and more of the type that depend upon hereditary factors. Hypertension, at least some forms of it, runs in families, and hypertension is one of the elements in the cardiovascular death rate. If we can find some therapy that will prevent the pressure from rising (and recent work shows promise), and if we are able to detect the members of the family who are potential hypertensives, then we may administer the medication, thus preventing or inhibiting the appearance for a long time of the heightened blood pressure.

The earliest onset of diabetes may be detected if the physician is watching for it in members of a family in which it occurs. By proper dietary régime and administration of insulin, the full effects of the disease may be prevented. Cancer of the rectum may be forestalled by removal of the polypoid growths in persons as yet unaffected with cancer. Cancer of the uterus may be prevented in some women whose female relatives are prone to develop cancer of the uterus by having the uterus removed after the number of children desired has been born. Numerous examples of the preventive side of hereditary diseases will occur to the alert practitioner.

Advice to Parents

One of the direct means of preventing hereditary disease is, of course, not to have the potential victims of the disease procreated. If a woman has given birth to one boy with hemophilia, the voluntary restriction of her family will pre-

vent subsequent sons in which the disease might develop. Since she will have no more daughters who may have sons to bleed, she prevents the disease from being passed on to future generations. A woman who has had one child die or lose his sight from retinoblastoma can limit her family, thereby preventing other potential victims from being born. If the hereditary disease is one which appears early in the life of the individual, then family limitation can be of value in wiping out the disease; but if it is one that appears when the child is fully grown, then the mother has probably had all her children before she knew of the defect in her offspring.

If the disease is one that is deleterious and is transmitted as a dominant, then the affected persons can refrain from procreation if the defect appears early enough in their lifetime; or if it be one which occurs after the persons have had their offspring, but is undesirable, then *potential* victims of it should not have children. Thus a man or woman, one of whose parents has developed Huntington's Chorea, stands an even chance of inheriting the disease. It may not show up in them until 45, but it so completely wrecks the life of the patient that such persons should not reproduce even if they are not sure that they have inherited the malady. Just one generation of refusal to bear children on the part of those whose parents have developed this disease would mean its elimination.

We must use our common sense in giving advice in this field of preventive medicine. If the defect or disease is one which has not been appearing until the patient has lived a long useful life, not only is it useless to try to prevent the disease from being passed on, but it is undesirable to do so. Take cancer, for example. If a man dies of rectal cancer at 70, one can not breed out that disease from his family, for all his children and probably all his grandchildren will have been born before his disease overtakes him. The only way to wipe out cancer from that family would be for all his descendants who were still young enough to procreate to refrain from reproducing. It would be far better to have them and their descendants as good citizens for 60 or 70 years, dying of cancer in old age, than to have their stock lost to the community in order to wipe out that strain of cancer. Moreover, it is not at all certain that they have inherited the factors for rectal cancer; or, if they have inherited them, it is not at all certain that they will live long enough to die of their inherited condition, because death at an earlier age from some other disease is likely to occur. If, on the other hand, it is a tumor such as retinoblastoma which is taking the child at an early age, and which either means death or disfigurement, those who are likely to have offspring with such a tragic inheritance should refrain from reproducing children whose heritage is far from being a goodly one.

If one's mental and physical endowment is good through a long lifetime, and if the hereditary disease is not one which means leaving the patient for years to be cared for by the community, it would seem unwise to attempt to breed out the hereditary disease. If it is one that is devastating in its effect, and appears at an early age, parents have no moral right to bring children into the world who may suffer from such diseases, if they know that such probabilities exist. The final balance must be struck after weighing the time of onset and balancing the good qualities that the patient may inherit against the undesirable ones which are also to be his portion. Unless the onset is late and the good far outweighs the bad, then it were better to

> Cancel from the scroll,
> Of Universe, one luckless human soul,
> Than drop by drop enlarge the flood
> which rolls,
> Hoarser with anguish as the ages roll.

A knowledge of inheritance is of value when the physician is asked to give advice to a mother who has had a malformed child. She wants to know whether she is likely to have another such mishap. No matter how rare the defect, the physician can not assure the parents that such a mistake can not occur again and that subsequent children are certain to be normal. If such assurances are given, the unexpected often happens and the mother has a second defective child. It is heartbreaking for the parents who have relied upon the doctor's assurances when such an accident occurs and it is detrimental to the doctor's prestige, and not infrequently loses for him the family and their friends as patients. Following are a few examples known personally to have occurred. A mother who was an elderly woman at the birth of her first child had the tragic experience of having it bleed to death from hemorrhage of the lungs at one day. This occurred before the days of Vitamin K. Feeling that she had perhaps not had the best prenatal care in the village where she lived, she went to a city during her next pregnancy and placed herself under the care of a specialist for several months before the second child was born. The same thing happened, and her child bled to death before it was one day old. But she had undergone that second pregnancy after she had been told that "It could not happen again." Another mother whose first baby had a trident hand was informed that nature might play that trick once but not twice in a family. Her second baby was a duplicate of the first, and the family changed doctors.

With some defects, one can almost, but not quite, guarantee that the mother will not have other children similarly deformed, while with other defects it is almost certain that she will have other children similarly affected. Thus a mother who has had one anencephalic baby is likely to have a second malformed child who probably will also be anencephalic. A mother who has had a baby born with an arm missing can not be assured that her subsequent children will be all right, but the chances are much in favor that they will be normal, especially if the parents were not related.

The Physician as a Record Gatherer

Not only should the physician be trained in genetics for the added breadth of knowledge it affords him, for the greater benefit which it brings in diagnosis, treatment and prevention of disease, but he should know what is of value for genetic records. The geneticist is not in a position to gather the data from which the general principles of human genetics are drawn; the physician is the only one who can do that. But he is not trained and hence much of his record taking is useless for the medical geneticist who would use his data together with those of other physicians for formulating laws. Thus in reporting a case of inherited disease, he may inquire as to whether the parents were related, but if they say no, he does not record that fact. The geneticist does not know if this point of consanguinity was inquired into, and the answer found to be negative, or if the physician never thought to ask about it, in which case the parents might have been related. Again the child with the disease may be the only one affected in the family. If the record states that there were four other normal children, the record is of value, since it serves for pedigree analysis; but if the record does not state whether there were other sibs or if so, how many, such a record is worthless. If repeatedly large families of ten or twelve children are found with but one child affected, then one is constrained to find some other interpretation than that the disease is dependent upon a recessive gene substitution. A few such families are expected, but they should not be in the majority. Hence

the number of sibs is important, and the genetically trained physician is so aware of this that he would not omit such information from his record.

The age of onset is important. If the disease begins at 15, and the patient is the oldest in the family, the fact that the younger sibs under 15 are unaffected does not mean that they are necessarily normal. They may develop the disease later on. But if all were older than the patient, it might be assumed that they were really normal. The genetically trained man will realize the importance of such information and record it.

He will not speak of the patient as "it" or "the child" or "the patient" but will give the sex, for some diseases are more prone to occur in one sex than the other, and the mode of their inheritance may be determined by the sex distribution. Therefore the sex will be recorded. All the other data will be recorded briefly and in usable form.

The Importance of Records on Twins

The genetically trained physician will appreciate the importance of twins in the field of genetic research and will not only keep records on all pairs of twins among his patients, but will record them in the literature in usable form. He will not select cases in which both twins were affected with a similar condition, but will report as well *all* cases in which one twin only was affected. He will know that any conclusions he reaches on identical twins must be controlled by similar observations on fraternal twins. Records will not appear in which the following are not clearly stated: (1) the sex of both twins, (2) whether they resemble each other very closely, or are unlike, and if possible (3) what their blood groups, their coloring, their physical measurements are, and (4) pictures of well-taken finger prints, so that the reader can estimate the validity of the criteria upon which their mono- or di-zygosity was judged. More careful examination of the membranes will be made before it is stated that the twins were monochorial, and hence from one egg, especially if the two show widely dissimilar characters. The possibility that the twins are from two eggs, that the placentae have fused, and that the membranes also have closely fused, giving the appearance of but one chorion, when there are in reality two, will be considered, and the true state of affairs recorded. Perhaps no one man will see enough twin pairs with any specific inherited trait to make his own records worth analyzing, but if his records are published, they will be a veritable treasure house for the trained medical geneticist.

The physician who is the guardian of his patient's health, who is the adviser and friend of his patient, will find his ability to diagnose and treat that patient's ills enhanced, and his counsel better founded if he is genetically trained. Moreover, he may become a true research worker, not in the laboratory with chemicals or animals, but in the realm of human genetics, by painstakingly recording the accurate details of his patient's background as well as of his hereditary illness, and by making these available to the geneticist who can analyze them accurately. Many physicians regret their inability to do research through lack of time, lack of money, lack of facilities for undertaking the study of some problem. The field of human heredity offers them their greatest opportunity; for there is scarcely a physician who does not encounter some case that offers chance to contribute valuable data toward the solution of some genetic problem.

AMATEUR SCIENTISTS AND THEIR ORGANIZATIONS

By W. STEPHEN THOMAS

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TO-DAY, "amateur" and "professional" are terms used with increasing emphasis in reference to many spheres of human endeavor. From athletics and politics to literature and gardening we make a distinction between the person who carries on a certain activity for his livelihood and another who engages in it for quite different reasons. Science is another domain in which sharp differences are drawn between amateur and professional participants. Although we can not forget that amateur can be used in the sense of dilettante or trifler, when we speak of an amateur scientist we mean one whose interest in science takes the form of a leisure-time hobby or avocation in contrast to the professional who has formal training and makes his living in his chosen field. In this latter use, the word "amateur" conveys the same meaning as when employed in a sporting sense, a connotation which is, indeed, a favorable one.

Not more than a generation or two ago scientific research had not yet been dignified as a profession. Priests, teachers, doctors, artists and laymen of many sorts carried on important investigations and made outstanding contributions to the sum of knowledge. Leeuwenhoek, Herschel, Darwin and Mendel are a few of the brilliant figures who did not make their living from science. To-day, thousands of persons throughout the United States, especially those in urban and suburban communities, are following scientific pursuits as a form of recreation. These do not include that equally large body who make their daily bread from science in one way or another. Most of these avocational scientists or amateurs are educating themselves in many branches of scientific knowledge; a major portion of them are learning scientific techniques. A great many are recording facts and compiling data which will be useful to professional scientists. A few are making original contributions to knowledge.

Concrete examples of amateur aid to science come readily to mind. Among these, the work of the amateur astronomers has deservedly attracted attention, while the collective efforts of the Society of Variable Star Observers, a selected group of these amateurs, has a high ranking in original investigation. We may mention, also, the amateur botanists, entomologists, geologists, mineralogists and zoologists, who, here and there, have advanced knowledge throughout the land by making collections and recording data on the distribution, ecology and life-histories of plants and animals. Although the volunteer observers, stationed throughout the country assisting the United States Weather Bureau in keeping records, are essentially compilers, they are amateur scientists. In a similar category are the bird students whose check-lists of species are invaluable records and whose work in banding aids specialists in probing the mysteries of migration. In far smaller numbers occur the amateur chemists and physicists, but these devotees are none the less represented. On the other hand, in the many branches of the applied and social sciences such divisions as agriculture,

horticulture, archeology, aviation, economics, history, mechanics, photography and radio can claim hosts of leisure-time enthusiasts. In numerous cases the skills and abilities of these amateurs are pronounced, so much so that important contributions have resulted from their efforts. To specify but two examples, one can point to the rapid developments in color photography and radio which are achievements for which amateur experimenters are given much credit. Very appropriately, Dr. Edwin G. Conklin has said, "Some of the best work ever done in science has been by amateurs and the spirit which has led them on has been the spirit of adventure and discovery. . . . It is essential for the normal development of human beings that this spirit should be cultivated and it is highly important for the development of science itself."[1]

Apart from the contribution of amateurs to the advancement of science lie other reasons why professionals, as well as the public at large, should ponder upon the significant role which may be played by these laymen. Science, to-day, has many more social implications than it had in the past. People whose everyday lives are materially improved by the discoveries and applications of science often feel they have a duty to acquire a general understanding of it. Furthermore, the future of research is a matter closely concerned with the attitude toward science held by the man in the street. It is quite likely that, in the future, financial aid for original investigation will come less from private and semi-private sources in the form of endowments for scientific and academic institutions and more from the public in the form of taxes. On this account, if for no other reason, the general public will need to know more about science and the scientific method.[2] Laymen of all types, who have gained practical experience in some scientific specialty such as the collection and classification of insects, or, let us say, the construction and use of a telescope, would certainly tend to have a more intelligent comprehension of science, both in fact and in method, than individuals limited to sporadic reading or forgotten school and college courses. At the same time, the person with a scientific hobby can be an interpreter of technical subjects to his neighbor. He can serve as a liaison between the research scientist and the common man in diffusing the spirit of science. It is this spirit of the scientific method that, above all things, must be imparted. It shows itself in the estimating of evidence, in the training in facts rather than fancies and in the use of the trial-and-error method of thinking. For every one to-day, nothing is more needed.

To popularize science in the best sense is a difficult task. Lately, considerable thought has been directed to this problem. A survey made in 1934 by Dr. Benjamin C. Gruenberg revealed the startling fact that of all the offerings in adult education only from five to six per cent. were in fields of science.[3] Here was one factor to account for public ignorance, namely, the lack of opportunity for learning about science. The situation evoked the question as to what suitable means might be used to bridge the gap between science and the public. Were formal educational methods, such as books and courses the only way, or might there, perhaps, be other avenues of approach?

In order to make a specific experiment testing the possibilities of amateur education in science in a limited area, Dr.

[1] E. G. Conklin, "Activities in Science in the Philadelphia Area." A circular of information. American Philosophical Society. October, 1939. No. 1.

[2] Morse A. Cartwright, *Jour. of Adult Education* 11: 3, June, 1939. p. 356.

[3] Benjamin C. Gruenberg, "Science and the Public Mind," p. 141. McGraw-Hill, N. Y., 1935.

Frederick P. Keppel, president of the Carnegie Corporation of New York, requested the American Philosophical Society to undertake a survey and program of action through a special committee of its members.[4] This Committee on Education and Participation in Science, composed, for the most part, of research scientists distinguished in their fields, were members of the society and outlined the policy of the program. The group consisted of the following: Dr. Edwin G. Conklin, *chairman,* Drs. Anton J. Carlson, Karl K. Darrow, Luther P. Eisenhart, C. E. Kenneth Mees, Oscar Riddle, Harlow Shapley, George G. Simpson, W. F. G. Swann, Edward L. Thorndike, Harold C. Urey and Roland S. Morris, *ex-officio.* The project, inaugurated in June, 1939, was not only directed toward amateur scientists but emphasized the actual participation of these persons in scientific activities. An area within 30 miles of Philadelphia was chosen for study. The result of the findings of this Committee on Education and Participation in Science, operating with an executive staff of scientific consultants, was to inaugurate a series of volunteer programs to test the effectiveness of amateur efforts, both as self-education and as an aid to science. However, the aim of this article is to reveal and interpret some of the data concerning the whole subject of the amateur and amateur science. First, the characteristics and interests of the former will be discussed; and, second, there will be examined the organizations which have been formed to accomplish the multiple aims of recreation, self-education and original research. Although the data used were obtained in the Philadelphia area, it is believed that the facts will serve to represent other regions as well.

[4] Frederick P. Keppel, "Responsibility of Endowments in the Promotion of Knowledge," American Philosophical Society, *Proceedings,* Vol. 77, No. 4.

The Amateur Scientist

There are not a few reasons why the general public should be rather vitally concerned with increasing its understanding of natural phenomena as well as acquainting itself with the various sciences applying to our universe. The rising educational level, manifested in part by the growing number of high-school and college graduates throughout the country, together with a greater diffusion of general information through print, motion pictures and the radio, are influences leading to a greater alertness of our people. One specific indication of this fact is the growing desire of some individuals to learn more about their environment and to enjoy it intelligently. City populations, thanks to the bicycle and automobile, are not restricted to their urban background. They can move cheaply and quickly to the out-of-doors. Combined with shorter working days and longer vacations, these factors increase the range for action in one's leisure-time. We see evidences of these influences in the hiking and camping fervor which sends annually into the mountains and woodlands hundreds and thousands of young and old persons and, again, in the broadening influence of gardening on great numbers of dwellers in the suburbs and in the growing desire to know more about and to protect wild life. All these tendencies relate closely to an inquiring attitude toward the sciences upon which forestry, biology, horticulture and conservation are based. Immediately connected with the applied sciences are the daily interests of persons in the machinery and gadgets which are interwoven with our modern living. The mechanical precision and technical proficiency of the automobile and airplane engine, the radio set and the camera have captured the imaginations of hosts of laymen who wish to know more about mechanisms and their functions.

Such curiosity often leads to the sciences lying behind these inventions.

Who, then, is the genuine amateur scientist? For our purposes, he, or she, is the one seriously enough interested to participate in some activity in science as a leisure-time pursuit. First of all, he follows his hobby for the sheer joy he derives from it, but that hobby, generally speaking, represents a sustained and, often, consuming interest. There is frequently an esthetic and intellectual appeal. Second, it is an interest which involves self-learning and self-improvement in most cases. In this respect it is more than a mere pastime. The means of learning about a subject and mastering it by the hobbyist may be conventional or they may be self-devised and ingenious. One interesting point to consider is that so many amateur pursuits in science involve the use of both hand and brain. Furthermore, almost all amateurs who have advanced in their fields of science have perfected some skill or technique. Finally, and third in the list of characteristics of scientific amateurs is the desire on the part of the more advanced of them to do original work or investigation which will add to the sum total of knowledge.

To supplement and clarify such statements as the foregoing it may be helpful to supply some detailed information. As part of the committee's preliminary study, a survey was made of a selected group of 300 adult men and women who had active interests in science. These persons were interviewed by the writer through the means of a questionnaire, filled out at twelve different meetings held by amateur clubs and societies, adult night schools, institutes and museums.[5] The individual tastes of these persons showed a wide diversity. The twenty-eight different fields of science which were indicated as holding interest are as follows:

anthropology
archeology
astronomy
aviation
bio-chemistry
botany
chemistry
embryology
entomology
fish culture
general natural history
general science
geology
geography
horticulture
mathematics
medicine and public health
metallurgy
meteorology
microscopy
mineralogy
oceanography
ornithology
photography
physics
psychology
radio
zoology

Now, it will be seen that these hobbyists are not only the amateur astronomers who grind lenses or are the banders of birds, but, also, the gardeners, radio operators, fish culturists and many others who, in the course of their recreation, follow bypaths inevitably leading to scientific inquiry. Many individual cases may be cited demonstrating how intelligent curiosity may bring about worthwhile results in the form of a permanent and active interest in a subject. There is the actual instance of the city-dwelling insurance salesman who, on a country walk, wondered about the inclination of bees for certain types of pollen. This curiosity induced him to become not only a skilled apiarist but a student of cross-fertilization in flowering plants. Other real cases are the railroad lampman who carries on experiments in physics and the real estate broker whose daily route through a mid-city park resulted in his becoming an authority on bird migration in his territory.

In making this analysis, there are some additional and pertinent facts revealed by the committee's study which are worth mentioning. One of these is the average age of the participants. Out of the 266 persons who reported their age, the mean was 36.5 years, and of the whole group of 300, 64 per cent.

[5] W. Stephen Thomas, Committee on Education and Participation in Science, American Philosophical Society, Progress Report No. 2, February 22, 1940, p. 6 (unpublished).

were men and 36 per cent. were women. The survey also revealed some interesting points concerning the amateur as a human being. That the average representative leads a well-balanced life seems to be indicated by the non-scientific interests listed. Recreations varying from golf and tennis to bridge playing and knitting were often mentioned.

As for the daily occupations of these people, 91 per cent. were employed and 9 per cent. were not regularly employed, but of these, at least half were either in the leisure class or had retired because of age. In the midst of the present situation of wide-spread unemployment in many fields, this last factor is an interesting commentary. In all, some 77 different occupations were represented by these science-minded laymen and laywomen. Twenty-one per cent. of the total, or 64 persons, followed some of the professions, being engaged in engineering, law, medicine, the ministry or teaching. Seventeen per cent. were occupied in business or office work of the white-collar type. Fifteen per cent. were skilled workers, including mechanics (3), printers (4), patternmakers (3), brick masons (2), a wood carver, a wool dresser, a plasterer, a carpenter, a postman, a police sergeant and a restaurant counterman, to mention a few of the various callings. Students made up 9 per cent. of the total number, but the majority of these seemed to have interests in science aside from their studies. And, finally, 6 per cent. were scientific workers or technologists, including one astronomer, nine chemists, a pharmacist, a photo-mechanic and a mineralogist.

Amateur Scientific Organizations in a Metropolitan Community

A desire to share one's interests with a group of congenial persons is often manifest among amateur scientists. This tendency is particularly shown by persons in the beginning stages of a hobby. Sometimes, if sufficiently advanced, the amateur later becomes a confirmed individualist and avoids a group. But, generally speaking, the club spirit prevails. It is, also, an incentive to productive amateur work. Dr. H. L. Hawkins writes of a similar situation in respect to amateur scientists in Great Britain:

> Sociability is, however, the key to the success and almost a *raison d'etre* of a local (amateur scientific) society. Unless this is an association of friends, it belies the name and loses its efficiency. It is not in the academic eminence of its members, but in the spirit of cooperation and enjoyment that the value of the society lies. . . .[6]

The selected amateurs, interviewed in connection with the Philadelphia survey, showed the important part which organizations play in stimulating and promoting interest. Forty-nine per cent. of the whole group questioned belonged to one or more amateur clubs, while 41 per cent. expressed a desire to join one or more additional organizations, despite the fact some of them were already members of groups. Several of these last-mentioned persons stated their wish to become members of clubs in fields in which no amateur organizations now exist in their locality. These fields were anthropology, chemistry, metallurgy, meteorology and psychology.

It was precisely because of the importance of the amateur scientific organization and its role in creating a wider understanding of science that the American Philosophical Society's committee, through its executive staff, made an intensive study of the groups in the Philadelphia region. They found here 287 clubs and societies, representing a total of 32,000 members, which, in the broadest sense, were concerned with the sciences. These organizations may be divided into two main groups. First,

[6] H. L. Hawkins, *Science*, 90: 2334, 262, September 22, 1939.

those with interests strictly in the pure sciences and these include the amateur astronomers, botanists, chemists, entomologists, microscopists, etc. There were approximately forty of these; and, second, a much larger division of more general scope. Under this category are placed the members of garden clubs, the aviation hobbyists, the amateur photographers with 85 separate clubs, the radio amateurs (1,700 licensed operators) and, lastly, a very large body of hunters and fishermen.[7]

While viewing the picture of amateur groups in and around Philadelphia, the third largest city in the United States, it seems worthwhile to touch, for a moment, on the significant background of this metropolis as a center for research and education in science. In colonial days medical teaching and practice gained an early foothold in the city. The University of Pennsylvania, the Library Company and the American Philosophical Society, all founded in the early eighteenth century, were other factors contributing toward making the city a focal center of learning. The last-named institution, with an intercolonial membership for promoting useful knowledge, was an especially potent force. In its early years it was virtually an amateur group and played a leading role in stimulating that spirit in the sciences. Residents of the city, frequently lawyers, ministers, merchants and often physicians, showed a bent for the physical and natural sciences as diversions. Prominent among them were figures like Benjamin Franklin, with his experiments in electricity; David Rittenhouse, clockmaker, and the Reverend John Ewing, a minister, both eminent contributors to astronomy; John Bartram and his son, William, among the earliest botanical students in America; and the physicians, John Morgan, Benjamin Rush and Casper Wistar, who had interests in a number of the sciences.

Another influence for such activity was the Quaker attitude. Members of the Society of Friends often showed strong leanings toward the sciences as recreational pursuits. With art, music and dancing frowned upon as worldly pastimes, activities of a scholarly type, such as archeology, bird study, botany and horticulture, were undoubtedly welcome as esthetic and intellectual outlets. Leading Quakers who distinguished themselves in these fields were the Bartrams, already mentioned, James Pemberton, merchant and philanthropist, who collected materials on the Indians, Thomas Say, the entomologist and zoologist, and William Darlington, the botanist, to mention but a few.[8]

In the first quarter of the nineteenth century a strong influence toward popular diffusion of science in the vicinity of Philadelphia gave rise to several academies and institutes which were established and supported chiefly by laymen. The oldest of these is the Academy of Natural Sciences of Philadelphia, founded in 1812 entirely as an amateur venture. It was started by two manufacturers, two physicians, a dentist, a chemist and an apothecary. For most of the years of its existence the academy has had affiliated with it America's leaders in descriptive biology and the earth sciences. The academy to-day is important as the meeting place of ten active amateur scientific societies, representing a membership of over 1,800 persons. Nearby is the Franklin Institute, founded in 1824 for the study and promotion of the mechanic arts and applied sciences. At the present, its large modern museum of hundreds of action-exhibits cover the physical sciences and graphic arts. These, together with the Fels Planetarium and public observa-

[7] Report of Committee on Education and Participation in Science, 1939. Yearbook of American Philosophical Society, 1939, pp. 353–364.

[8] Roland S. Morris, *The Friend*, Philadelphia, Pa., 113: 10, 173–174, November 1, 1939.

tory, make it a natural center for amateur interest with twelve such organizations meeting there.

The Wagner Free Institute of Science, founded in 1847, on the other hand, is the only institution in the city where adults may attend free lecture courses at night on chemistry, physics, engineering, botany, geology, geography and zoology. Three amateur clubs also meet here. Further removed from the city, in Media, county seat of Delaware County, is the Delaware County Institute of Science. This unique institution, started in 1833, also bears testimony to the spread of amateur interest in science both in the past and to-day. Here, under volunteer leaders, are enrolled men and women in autonomous groups in geology, mineralogy, foreign languages and other subjects. Other museums in the Philadelphia community available to amateurs scientifically inclined are the Commercial Museum and the University of Pennsylvania Museum, both notable in their specialties. The former is devoted to exhibits of commerce and geography and carries on educational services for the public schools. It also provides a series of free lectures for adults in geography and travel. The University Museum, concerned with archeology and ethnology, conducts research in these fields and maintains outstanding exhibits. It, too, features a free lecture course. From time to time, amateur archeologists and ethnologists have worked as volunteers on the staff.

However, the institutes and museums mentioned are not the only institutional facilities in and around Philadelphia available for stimulating amateur science. In addition, there are extension courses of colleges, adult night schools and other agencies. It must be noted, though, that the science content of such offerings is limited. The city is also rich in library resources of the reference or research type. Thirty-eight of them contain books in the general fields of the sciences. The Bibliographical Planning Committee should bring about cooperation for the most effective use of such valuable resources.

Philadelphia possesses other instrumentalities for broadening interest and knowledge in science. Its Fairmount Park system, consisting of 39 different tracts and areas, comprising a total of 3,838 acres, is the largest natural park region within the boundaries of any city. It offers innumerable opportunities for field studies in natural history. Situated in Fairmount Park are the Zoological Gardens, maintained by the Philadelphia Zoological Society. It is the oldest institution of its kind in the United States with an important collection of animals, whereas its educational program is broad and is an important influence in the city for popularizing science. Also located in Fairmount Park is the city-owned Aquarium and the Horticultural Hall. In and about the metropolis are a number of arboreta and botanical gardens, public or semipublic in function. Largest is the Morris Arboretum in Chestnut Hill, owned and run by the University of Pennsylvania. Finally, as a resource for scientific education and research are the seven observatories in the Philadelphia district accessible to amateurs. In all, there are some 164 separate institutions or other potential centers for amateur use. The American Philosophical Society's committee is now preparing a guide to all these.

Now, turning to those various clubs and societies formed to meet the needs of thousands of leisure-time scientists, we shall appreciate their function more fully after having examined their background. The following statements are based on analysis of 30 of the most active groups devoted to the physical and natural sciences. By means of question-

naires, visits to organizations and conferences, the executive staff has compiled this list. The executive staff consists of Roger Conant, curator of the Philadelphia Zoological Garden, in zoology; Dr. John M. Fogg, Jr., assistant professor of botany of the University of Pennsylvania, in botany; Dr. Serge A. Korff, Bartol Research Foundation, in physics and astronomy; Dr. Edward E. Wildman, of the Philadelphia Board of Public Education, in education and general science; and the executive secretary, W. Stephen Thomas, formerly director of education of the Academy of Natural Sciences of Philadelphia. The following amateur scientific organizations which were studied, together with the total number of members of each, as reported late in 1939, are as follows:

Organization	*Number of Members*
1. Aero Club of Philadelphia	130
2. Amateur Astronomers of The Franklin Institute	50
3. American Entomological Society	65
4. American Meteor Society—(In Philadelphia area)	8
5. Bird Club of Philadelphia	80
6. Botanical Society of Pennsylvania	120
7. Burholme Bird Club	35
8. Comstock Society	85
9. Delaware County Institute of Science	225
10. Delaware Valley Naturalists' Union	75
11. Delaware Valley Ornithological Club	150
12. Eastern Bird Banding Association	150
13. Frankford Mineralogical Society	25
14. Geographical Society of Philadelphia	430
15. Junior Zoological Society	20
16. Leidy Microscopical Club	30
17. Naturalists' Field Club (U. of P.)	30
18. Pennsylvania Fish Culturists Association	300
19. Pennsylvania Forestry Association	650
20. Pennsylvania Parks Association	1,400
21. Peregrine Club	15
22. Philadelphia Botanical Club	89
23. Philadelphia Geological Society	58
24. Philadelphia Mineralogical Society	127
25. Philadelphia Natural History Society	46
26. Philadelphia Council of Camera Clubs	31
27. Rittenhouse Astronomical Society	205
28. Society of Natural History of Delaware	126
29. West Chester Bird Club	60
30. Wissahickon Bird Club	104
Total Membership	3,899

With but one exception (the Philadelphia Geological Society whose membership is semi-professional) this list includes amateur groups. For that reason, professional and academic organizations were not considered in this study, though records and statistics concerning them have been gathered by the committee. Illustrations of the professional type are such well-known bodies as the American Association for the Advancement of Science, American Association of Scientific Workers, American Institute of Chemists, American Chemical Society (Philadelphia section), Pennsylvania Chemical Society, American Gem Society and many others. These would not exclude teachers' organizations, clubs and seminars formed in affiliation with the scientific departments of colleges and universities. But all of them are, or should be, interested in amateur scientific endeavor and should be of potential service in giving advice and, where possible, should provide leadership.

In turning to the analysis of the selected organizations grouped above, a prime concern of the committee was to discover the causes motivating the organizing of these bodies. Scrutiny of their constitutions showed that the expressions "to promote interest" in one subject or "to diffuse knowledge" of another were most frequently used. Actual count revealed that 67 per cent. of the thirty clubs considered education of the members and of the public at large as their chief aim. On the other hand, 30 per cent. indicated that orig-

inal investigations in the fields of science concerned came first in the interest of the group. Several organizations expressed this purpose as "the improvement and advancement" of their subject through original research. Only 3 per cent. seemed to put any emphasis on the social features of their meetings.

Activities of the thirty amateur clubs and societies studied fall into eleven different classes. The number of clubs engaged in these activities is shown in the following table:

1.	Meetings	29
2.	Reports by members	28
3.	Lectures and talks by guest speakers	29
4.	Demonstrations, incl. use of pictures, specimens, apparatus	23
5.	Maintenance of scientific collections	12
6.	Field trips	25
7.	Keeping records	19
8.	Publications	12
9.	Maintaining library	12
10.	Exhibitions	11
11.	Owning laboratory or apparatus	1

Any analysis of the sort attempted by the committee would have lacked some worth had it failed to reveal the actual part taken by members in the activities of their respective organizations. This part of the study, based on figures of attendance at meetings, participation in discussion, the making of reports and the attendance on field trips and in other functions, varied to a marked degree. In one instance only 3 per cent. of the membership took part, whereas in two other bodies, each small and selective, almost 100 per cent. of the members participated in amateur activities. However, the average participation for the total number of thirty groups was 47.2 per cent.

Another important fact brought out by the survey was that 85 per cent. of the membership of these clubs and societies in the course of their recreation in science utilized some form of skill or technique. These techniques varied from the ability to identify, classify and prepare many types of organic or inorganic material to the construction and manipulation of apparatus and instruments. The latter included cameras, microscopes, telescopes, radio instruments and even airplanes.

As the effectiveness of most professional scientific research depends upon its availability for use through publication, so, also, in amateur endeavor, publication of original observations, records and other data is a prominent factor. As noted before, 12 clubs, or 33 per cent., issued their own publications, though only 23 per cent. of the total membership actually saw their material in print. The publications ranged from creditable scientific periodicals, often with professional scientists such as museum staff members as editors, to more ephemeral bulletins and newsletters in mimeographed form. But it must be pointed out that these latter served as a medium for stimulating interest and spreading education among the members.

Although, as was previously indicated, approximately 30 per cent. of the various amateur groups emphasized pure research, it is to be remarked that the minutes, publications and other records of the organizations, as well as the scientific collections which are in many cases assembled, represent material of possible use in the promotion of knowledge. Especially does this fact apply to the natural sciences in which the seasonal variations in fauna and flora are recorded by field observers who may be amateur bird students, botanists, entomologists or the like. H. L. Hawkins, already quoted, wrote in this connection regarding amateur groups in Great Britain:

In the matter of research, the greatest contribution (other than encouragement) that can be made by scientific societies comes from their ability to keep, check, and publish records of

transient phenomena. Every recurrent seasonal event in nature invites and often receives accurate observation. . . . In such work the society as distinct from the individual has a special value; for records without independent confirmation are of uncertain use. . . .[9]

One fundamental disclosure of the Philadelphia study was the information concerning the needs of the various organizations in advancing the interests of their members and in promoting and diffusing science. In the course of its survey, the committee found that, although a majority of the groups seemed adequately organized for their own purposes, 56 per cent. of the total would profit by outside help and cooperation. More specifically, there was a need for coordinating programs and activities, exchanging speakers and increasing membership. Also desirable was more varied program material, such as demonstrations of scientific work and the provision of more visual aids in the form of good motion pictures and colored slides. Lastly, there was need to further the original work of members. Sixty per cent. of the organizations expressed the immediate need of new members. Several of the groups gave evidence that if new membership were not secured, it was doubtful if the club or society would long survive.

Several of the groups, more especially those in general natural history, showed a record of more pronounced activity thirty or forty years ago than to-day, with a decided falling off of interest and participation in the last ten years. The situation, however, did not apply to individual amateur naturalists working on their own. An interesting commentary on this condition is the fact that between 1900 and 1920, in the Philadelphia area, there were reported to be some thirty small but active amateur microscopical study clubs. To-day, there are but two. Twenty years ago, there existed in the region five organizations, each with several hundred members, devoted to the study and culture of aquarium fishes. At the present time, the Pennsylvania Fish Culturists Association is the sole representative of this once flourishing amateur interest. Equally significant, though, has been the growth of interest in astronomy and bird study, while in the applied sciences activity in photography and radio operation has accelerated tremendously in the last decade.

In examining the effectiveness of the divers bodies for stimulating amateur science, it was found that the most successful organizations were those which possessed within their ranks one or more scientifically qualified leaders. These moving spirits were not only experts in their subjects but delighted in working with those less informed and had the ability to interpret technicalities in a popular but accurate manner. In this connection, it can be pointed out that some relation with science in its professional aspects has proved continuously healthy for amateurs. That the meeting places of a number of the groups are placed in museums and similar centers has undoubtedly been one of the reasons why amateur science has flourished, not only in Philadelphia but in other communities. The easy access to scientists on academic and museum staffs and the availability of research material in the form of books and collections has done much to spur on the layman to contribute to the accumulation of scientific knowledge. Such relationships need to be strengthened and perpetuated. One means for bringing about this situation would be the formation of informal councils or advisory groups for each of the clubs seriously concerned with science to which qualified professional leaders would be willing to contribute advice and other assistance.

An immediate reaction to the questionnaires sent out by the committee and

[9] *Op. cit.*, p. 263.

the visits of its staff was the favorable attitude toward mutual cooperation. Tangible evidence of this feeling was the spontaneous movement for a council or affiliation of all the various scientific bodies within a thirty-mile radius of Philadelphia. Such an affiliation, semi-professional in nature, has existed in New York City as the New York Academy of Sciences and Affiliated Societies. Two other such councils have just been organized in Buffalo and Rochester, N. Y. In Philadelphia, a meeting of thirty delegates from twenty-five groups included in the survey held a meeting which appointed an organizing committee. The latter, in the spring of 1940, formally launched the Philadelphia Council of Amateur Scientists. This council pledged itself to act as a clearing-house for information, to coordinate the purposes and activities of the groups, to increase membership, exchange program material and to bridge the gap between science and the public.

In reviewing the role of amateur scientific organizations, one further consideration is not to be neglected. All these aggregates of leisure-time scientists, following many different branches of interest, have an important link with their immediate community. They represent groups organized for the mixed purposes of recreation, education and the promotion of knowledge. In this sense they are social agencies. They have, for that reason, a potential relationship to other local groups and organizations. It can readily be seen how schools and general educational bodies and these amateurs might work together to mutual advantage. An instance of this appears in the effective work which might be done with the large number of science clubs in the elementary and high schools, both public and private. These small clubs provide means for intelligent recreation after school hours, for they allow young people to learn about science by making experiments, collecting specimens and data and constructing apparatus. Adult clubs could aid, from time to time, by furnishing speakers and leaders and by affording stimulation through other means. On the other hand, these younger groups possess members who, at a later date, will be highly qualified to join the older organizations. This might be a possible solution to the dwindling membership in some of the adult groups. Another instance of future cooperation exists in the situation regarding the adult evening schools, flourishing in suburban communities around Philadelphia as well as in other localities. These self-organized schools for laymen are in need of practical courses and demonstrations in the pure sciences. But professional sources do not seem adequate to supply material and teaching personnel. Here is a case where local scientific clubs could provide enriched programs and leaders for teaching science and stimulating scientific activities and hobbies among the public. Also, in the field of recreation, such agencies as Boy and Girl Scouts and social welfare groups need trained leaders to supervise nature study, photography, gardening and many other branches which are forms of amateur science. Lastly, the amateur groups, each in its own locality, can serve as important interpreters of science not only through many formal educational means but through the example of their individual members.

UNIFYING SCIENCE IN A DISUNIFIED WORLD

Prepared for the International Institute for the Unity of Science
by M. B. Singer and A. Kaplan

THE first week of the European war coincided with the convening of an international group of distinguished scientists and philosophers to participate in the Fifth International Congress for the Unity of Science held at Harvard University. That forces for unification should be called out by a world in which disunification is wide-spread is not without historical parallel. Welcoming the two hundred delegates from nine countries, President Conant of Harvard called attention to the similar circumstances under which the Royal Society of England was founded three centuries ago "in a period of civil and religious strife." And to-day the scientist is even more closely concerned with the world around him, for science is frequently blamed and criticized for the part it allegedly played in bringing about the contemporary chaos.

The discussions at the congress exhibited the activities of the unity of science movement as proceeding simultaneously along three fronts: first, the coordination of the special sciences with one another through a coordination of the concepts and principles of the different sciences; second, making available the results of such unification for more efficient application of various sciences to the solution of practical problems in engineering, agriculture and medicine; third, applying the content, method and outlook of science to formal and adult education.

The last two phases were given special emphasis at the congress because of the influence American pragmatists and operationalists have had on the movement as a whole. This influence was explicitly acknowledged at the Harvard Congress by a paper commemorating the centenary of the birth of Charles Peirce, the founder of American pragmatism, and by an appreciative letter to John Dewey in honor of his eightieth birthday. The international movement, however, owes its origins to two groups of philosophers and scientists who met informally in pre-Hitler Berlin and Vienna to discuss the works of Ernst Mach, Bertrand Russell and Ludwig Wittgenstein. Since that time, the voluntary or forced expatriation of many of the Germans and Austrians has minimized the importance of geographical boundaries in the movement.

Although it is scarcely five years since it was officially organized, the International Institute for the Unity of Science is fast becoming responsible for a major movement in the scientific world. The Harvard meeting was held under the sponsorship of the American Association for the Advancement of Science, the American Philosophical Association, the Philosophy of Science Association, the History of Science Society and the Association for Symbolic Logic. The last two organizations, sharing members and interests with the institute, held joint sessions with the congress proper.

In the investigation of scientific method the unity of science movement has set itself the task of constructing, with the help of mathematics and symbolic logic, the skeleton of an exact language in which the logical connections of terms and laws of the different sciences could be precisely expressed. One of the innovations of the Harvard Congress was that

the language of the social sciences was given as much attention as that of the physical sciences.

The Harvard Congress was also unique in enlisting the interest and active cooperation of practical technicians to discuss the applied and social aspects of science. At the two sessions devoted to this subject papers were read by professional engineers and a representative of the U. S. Department of Agriculture. The discussions in this field were exploratory in nature and inaugurated consideration of problems in the history and sociology of science which will undoubtedly assume increasing importance in the process of unifying the sciences.

Of most significance to the general public are the implications of the unity of science for education. These were partly traced in a paper by an educator urging that much of the present aimlessness and incoherence in American education could be eliminated without imposing doctrinaire regimentation by utilizing the resources of the unity of science movement, and particularly by introducing into scientific curricula, even at high-school and elementary levels, a study of the history and logic of science.

For many members of the congress, especially for Dr. Otto Neurath, its permanent secretary, these implications reach beyond the classroom. He and his associates in the unity of science movement want to disseminate a scientific outlook among all literate adults. Ours is a scientific age and almost every one has some notion of what science is about. But the frequent misinterpretations and unwarranted extrapolations of scientific findings promulgated by careless or incompetent popularizations have created the important and difficult function of interpreting the results and methods of science to a large and interested lay public.

An essential stage in the performance of this function is to interpret the technical language of the sciences in terms of every day language. As Dr. Neurath formulates this task: it should be possible to translate Einstein's theory of relativity into a taxi driver's vernacular. The work that has already been done on the structure of scientific language makes this a far less quixotic objective than appears at first sight. Together with the pictorial techniques for presenting statistical data (Isotype), to which Dr. Neurath has also made important contributions, this work offers vivid and accurate tools to the adult education movement.

To promote this and the other phases of its activities the International Institute for the Unity of Science holds annual congresses, publishes a *Journal of Unified Science* (W. P. Van Stockum and Zoon, Holland; American agents: University of Chicago Press), directs the publication of monographs and books contributing to the movement through its "Library of Unified Science," and has just initiated a far-reaching project of constructing an "Encyclopedia of Unified Science" (University of Chicago Press), which will embody the progressive attainments of the movement.

The unity of science movement promises to become a fit expression of the twentieth-century scientist's social conscience by promoting mutual understanding among scientists, clarifying the nature of science—both in itself and as a force in human culture—and making possible smooth and accurate transitions from the professional world of the scientist to the everyday world of scientist and layman alike.

BOOKS ON SCIENCE FOR LAYMEN

FOUNDERS OF CHEMISTRY[1]

THOSE who enjoyed Mr. Haynes's entertaining sketches of the pioneers of American chemical industry, as they appeared serially in "Chemical Industries," have now the opportunity of rereading these interesting biographies in attractive book form. After a preliminary sketch of the many-sided efforts of John Winthrop, Jr., to exploit the undeveloped chemical resources of colonial New England, the author passes over the next century and a half in order to take up the real program of his volume, which is to give a vivid account of the founders of some of the leading chemical industries of the United States. These founders in nearly all cases established chemical dynasties whose histories through several generations of family control constitute the most interesting feature of the present volume. Details of business developments and transfers are interspersed with an abundance of anecdotal material so that the interest of even the most casual reader is well sustained. The sketches of the Rosengarten, Kalbfleisch, Mapes, Grasselli, Warner, Klipstein and other chemical founders all show similar traits of business capacity and enterprise not only by native sons of colonial ancestry but by later immigrants of British, French, Dutch, German and Italian origin. No small part of the early developments in American science and industry is due to the transplanting of European ideas and practices to the more stimulating environment of the new republic. The book is recommended not only to chemists and chemical manufacturers but to those who are interested in the origins of domestic industries and in the story of human relations.

C. A. BROWNE

[1] *Chemical Pioneers.* By William Haynes. Illustrated. xvi + 288 pp. $2.50. 1939. D. Van Nostrand Company.

FLOWERS OF THE DESERT[1]

JAEGER's "Desert Wild Flowers" makes one want to pack up the old flivver and start out to find the plants he pictures. Jaeger interprets "flowers" very broadly to include Piña and Palm as well as Cactus and Castilleja. The book is in fact a flora of the Southwestern Deserts, though the author departs from the formal order of a flora and dispenses with keys—which the reviewer would wish to have. But the species are figured, mostly with drawings which by lines or with simple shading catch and portray the essential features of the plants with unusual skill. To these are added a few photographs softly done on matte paper in a style at times almost worthy of a Corot.

It is easy to see that Dr. Jaeger is a teacher—though a zoologist rather than a professed botanist—for he advises his readers "to carry the book with them into the desert along with a box of colored pencils so that they may fill in the colors directly from the flowers. This if carefully done will not only greatly increase the attractiveness of one's copy of the book but will also impress the plant more firmly on one's memory"; and the paper of the book was in fact carefully chosen to take such color. Few users, however, will have either the patience or the skill necessary to color the fine detail drawings successfully. It is so much easier in these days to take Kodachromes far more accurate than hand-colored prints. This leads the reviewer to hope that the time is not far distant when the cost of reproducing pictures in color will come down to a point where every such manual will be illustrated in color. For a generation or more Europe has had popular floras with the flowers shown in color. Is it not

[1] *Desert Wild Flowers.* By E. C. Jaeger. Illustrated. 322 pp. $3.50. March, 1940. Stanford University Press.

time that America reached the same stage?

ROBERT F. GRIGGS

THE MIND GROWS UP[1]

THE present volume is the third edition but first English translation of a well-known work on comparative developmental psychology, written from the Gestalt point of view. The concept of comparative development is taken as fundamental, being illustrated by genetic parallelisms of behavioral development as observed from data in the fields of child psychology, social and ethnopsychology and anthropology, animal psychology and psychopathology. The book should be of especial concern to students of these fields, as well as to those interested in a systematic psychological science.

The author begins by contrasting the "mechanistic" and "organic" (*Gestalt*) approaches to psychological phenomena. The former term is used to denote any analytic or reductionistic schema for behavior description, as found in various forms of associationism, behaviorism or other stimulus-response psychologies. Werner cites the usual Gestalt arguments against this approach, and adopts the second or "organic" view, with its emphasis upon the priority of totalities or configurations. Werner's position is thus typical of the German *Struktur* or *Gestalt* psychology, with its historically related movements of the *Gestalt-* or *Komplexqualität*, the *Personalistik* and the *Geisteswissenschaften*. The central tenet of these various movements is that the study of mental *patterns* or *Gestalten* should take precedence over the more analytical study of elements, events or stimulus-response coordinations. Thus Werner states (p. 15):

> Development cannot be symbolized by a continuous, mathematically conceived line, but rather must be thought of in the form of typical mental patterns, with the relatively higher levels being understood as innovations emerging from the lower.

Werner then reports extensive data from child psychology, social psychology and anthropology, animal psychology and psychopathology, illustrating the "primitive character" of behavior in each of these fields. The material is classified as follows: (1) primitive sensori-motor, perceptual and effective organization, (2) primitive imagery, (3) primitive notions of time and space, (4) primitive action, (5) primitive thought processes. The author purports to find the same structural principles of mental organization to hold in the mental life of children, "primitive" peoples, animals and schizophrenics. Primitive mental life, in such cases, is held to be syncretic, diffuse, indefinite, rigid and labile. Animism, magic and synaesthesia are three illustrative examples from different fields. The course of mental (as well as biological, *e.g.*, neural) development illustrates increasing differentiation, subordination of parts and hierarchization. Increasing differentiation yields a "plurality of mental levels," the genetically higher levels being characterized as not syncretic, but discrete; not diffuse, but articulated; not indefinite, but definite; not rigid, but flexible; not labile, but stable.

Criticisms of the book can best be directed against (1) the loose use of terms, many of which can neither be operationally defined nor logically derived from others capable of operational definition, and (2) the Gestalt bias and complete disregard for other possibilities of interpretation. Thus, for example, there is no discussion whatever of the phenomena of conditioning, and no use is made of conditioned response principles in the interpretation of the data. In fact, there

[1] *Comparative Psychology of Mental Development.* By Heinz Werner. 510 pp. 1940. Harper and Brothers.

is no reference to conditioning in the index, and no apparent reference to the extensive work in this field in the otherwise excellent bibliography of 751 items. The obvious relevancy of conditioned response principles to many if not most of the data is illustrated by the following passage, taken as a random illustration from the discussion of "primitive abstraction" (p. 238):

> Again, concrete abstraction accounts for many verbal expressions for the qualities of objects the adult names for which the child has yet to learn. He may designate colors by naming familiar objects which characteristically exhibit these colors. For example, a boy four and a half years old is sorting color cards. He knows only the names "red," "blue," "white," and "black." When asked for the name of the yellow card he says, beaming with triumph: "The mail box!" (Australian mail boxes are yellow.) According to Descoudres' report there are small children who designate "brown" by "chocolate," "white" by "chalk," and "blue" by "pen-box." This is concrete abstraction. The imagined objects and the colored test cards together build up a configuration in which color is the dominant quality-of-the-whole.

Could Pavlov himself have furnished better illustrations of conditioning? And how much more precise and experimentally verifiable than the configural interpretation!

In spite of these serious limitations, however, the volume remains an excellent sourcebook of comparative developmental material. There is also a much-needed emphasis upon the relations between comparative developmental and general experimental psychology. For such methodological "insights" as well as for the extensive source material, the book should be read by every serious student of human and animal behavior.

JOHN P. FOLEY, JR.

MEN AND STARS[1]

THERE is no other book on, or rather relating to, astronomy similar to this one. Instead of directly discussing what has been learned about the universe beyond this earth, it meanders leisurely in and out of various subjects, some of which at first thought might not appear to be connected closely with the stars. In these excursions the authors at times are in the mythological days of Mesopotamia or Egypt; at others, in the beginnings of science in Greece or China; at others, on the frontiers of profound theories with Newton and Einstein.

Although the authors wander widely, their paths are not aimless. Instead, they have realized more fully than most writers how completely the somewhat austere frameworks of the astronomy of the professional scientists has been clothed by the masses of men with thousands of vague beliefs that together form substantial mass philosophies. They have written not only of the stars but much about men and their ideas of the cosmos.

The style of the authors is clear, entertaining and often really delightful. Many of their paragraphs are enriched with apt quotations from the writings of authors ranging from Homer to Lewis Carroll. Since they have limited their discussions largely to such subjects as the seasons, eclipses, constellations and navigation, to subjects which have been of interest since antiquity, many current astronomical problems are only briefly considered or omitted entirely. For example, the nature of the stars and the structure of the galaxy are touched rather lightly, though quite clearly and correctly. Extended expositions of what is known about such things would be severe and quite out of harmony with leisurely and friendly descriptions of familiar objects and of ideas mellowed by age.

"Stars and Men" is an excellent book and is deserving of a wide circulation.

F. R. M.

[1] *Stars and Men.* By Stephen A. Ionides and and Margaret L. Ionides. Illustrated. xvii + 460 pp. $4.00. 1939. Bobbs-Merrill.

HANS ZINSSER

PROFESSOR OF BACTERIOLOGY AND IMMUNOLOGY, HARVARD MEDICAL SCHOOL, WHO DIED ON SEPTEMBER 4, 1940, AT THE AGE OF 61 YEARS.

THE PROGRESS OF SCIENCE

HANS ZINSSER—SCIENTIST AND HUMANITARIAN

THE death of Hans Zinsser leaves many voids in the intellectual life of to-day. He was a distinguished scientist, an important commentator on medical education, a soldier and expert in military sanitation, an author and poet of great ability and popular appeal.

Reared in a family of great cultural attainments, his early education was somewhat unorthodox, but it gave him a substantial training in and an abiding love for music, art and literature. Many trips abroad (over twenty before his formal education was completed) and subsequent travels in pursuit of professional interests and duties in many countries—Germany, France, Serbia, Africa, Russia, Mexico and China—made him, because of his humanism, a true cosmopolite.

Until the summer of 1938 when the symptoms of his illness became apparent, his physical vigor and endurance had been great and showed no effect of age; his intellectual powers remained unimpaired to the end. We may only speculate over the possibilities of productivity in many directions which disappeared when that matured combination of great experience and a many-facetted brilliant mind ceased to operate.

He was born on November 17, 1878. He received his A.B. degree in 1899; his A.M. and M.D. degrees in 1903—all from Columbia University. Honorary Sc.D. degrees came from Columbia in 1928, Western Reserve in 1931, Lehigh in 1933 and from Harvard and Yale in 1939. He was, in turn, professor of bacteriology and immunology at Stanford University, 1910–1913, Columbia University, 1913–1923, and Harvard University, 1923–1940.

He accompanied the American Red Cross Sanitary Commission to Serbia in 1915, as bacteriologist. He served in the United States Army Medical Corps, attaining the rank of colonel, from 1917 to 1919. He was sanitary commissioner for the League of Nations to Russia in 1923. He was exchange professor from Harvard to the University of Paris in 1935, and to Peiping University in 1938. He was a member of 36 scientific societies, including the Association of American Physicians, American Philosophical Society, American Academy of Arts and Sciences and the National Academy of Sciences. His decorations were—Distinguished Service Medal, U. S. A.; Légion d'Honneur, France; Order of St. Sava, Serbia.

Dr. Zinsser's scientific work was almost wholly in the field of immunology and his researches have contributed many important elements to the structure of that science as it stands to-day. He was a bold and versatile investigator of problems concerning tuberculosis, syphilis, pyogenic diseases and the pathogenic filtrable viruses. From 1930 on he was occupied almost wholly with the many problems concerned with endemic and epidemic typhus fevers—etiology, transmission, immunology and epidemiology—to all of which he made notable contributions. His last success in the typhus field was the development of methods practicable for the mass production of vaccines for typhus fever and, incidentally, for Rocky Mountain spotted fever.

He is appraised in scientific circles as one of the outstanding bacteriologists and immunologists of his time. The public knew him best through his two delightfully written books, "Rats, Lice and History" (1935) and his autobiography, "As I Remember Him; The Biography of R. S." (1940). Medical students throughout the world know of him through his text-books of bacteriology and immunology, both of which have gone through many editions and translations into other languages.

In university circles, the breadth and

depth of his knowledge brought him contacts with the best minds in diverse fields of learning. He was an inspiring and enthusiastic teacher of medical students. A leader in research, he attracted students from many countries; they received from him education in many things outside of science because he discoursed freely with all his associates and was wholly devoid of academic affectation.

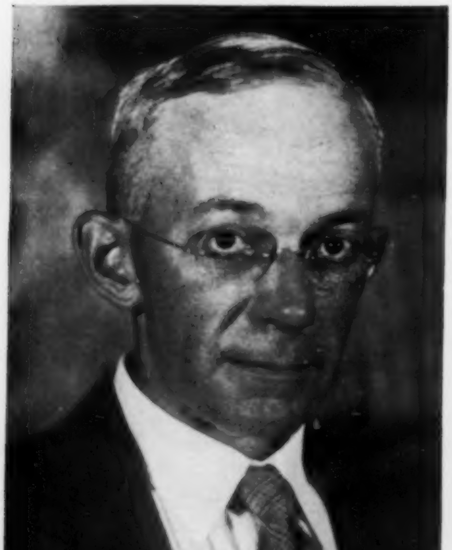
His was a sensitive nature, quick to respond in defense or aid, wrath or sympathy, as occasion warranted. As Professor Walter B. Cannon has said: "The wide range of his interests, his sense of humor, his skill as a musician, his exuberant spirits and infectious enthusiasm and his warmly affectionate nature made him a delightful companion and, to those who knew him well, one of the choicest of friends."

S. B. Wolbach
Harvard Medical School

THE AMERICAN ASSOCIATION ADVANCES SCIENCE

On the general program of the meeting of the American Association for the Advancement of Science held in Philadelphia from December 27 to January 2, the titles of more than two thousand addresses and papers appear. It is difficult to visualize such a volume of scientific contributions. If the papers were presented sequentially before the association as a whole, and if the average length of time required to read a paper were fifteen minutes, the meeting would continue more than 500 hours, or two months at eight hours per day. Consequently, it is necessary to hold many sessions simultaneously; in fact, as many as forty-five are to be held at one time.

Two distinct kinds of sessions are held at the meetings of the association. There are sessions at which specialists present before other specialists in the same field the results of their most recent investi-



DR. A. B. COBLE
PROFESSOR OF MATHEMATICS, UNIVERSITY OF ILLINOIS; CHAIRMAN OF THE SECTION ON MATHEMATICS.

DR. GEORGE SCATCHARD
PROFESSOR OF CHEMISTRY, MASSACHUSETTS INSTITUTE OF TECHNOLOGY; CHAIRMAN OF THE SECTION ON CHEMISTRY.

ROBERT R. McMATH
DIRECTOR, MCMATH-HULBERT OBSERVATORY, UNIVERSITY OF MICHIGAN; CHAIRMAN OF THE SECTION ON ASTRONOMY.

DR. LEON J. COLE
PROFESSOR OF GENETICS, UNIVERSITY OF WISCONSIN; CHAIRMAN OF THE SECTION ON ZOOLOGICAL SCIENCES.

gations. There are other sessions at which distinguished scientists present surveys of rather broad fields of science. The former, roughly speaking, are analyses, while the latter are syntheses. Science marches in two columns, each of which is necessary for the continued advance of the other.

As I have said, there are sessions for the presentation of technical papers by specialists. These sessions are analytic in character because they pertain to one of the narrow fields into which science has been analyzed. When the association was founded ninety-two years ago, science consisted of natural philosophy and natural history. Natural philosophy, generally speaking, included the mathematical and physical sciences; natural history, the biological sciences. Very soon subdivisions of these fields were organized. Now the association has fifteen sections, including the humanities—if the word has any definite meaning. But this is not all; one hundred

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DR. KARL M. DALLENBACH
PROFESSOR OF PSYCHOLOGY, CORNELL UNIVERSITY; EDITOR, *American Journal of Psychology;* CHAIRMAN OF THE SECTION ON PSYCHOLOGY.

and seventy-four other scientific societies are affiliated with the association, many of which meet with it regularly. They range from societies organized for the advancement of such universally known subjects as astronomy and physics to such recently recognized subjects as rheology, psychometry and photogrammetry. A wag once said that specialists in such narrow fields are scientists who learn more and more about less and less. There is some truth in the quip, but in

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fairness all the emphasis should be placed on the "more and more."

It is the other aspect of science, the synthetic, as it appears in the meetings of the association, which I wish especially to consider here. In addition to the general sessions, open to all scientists and the general public as well, there are formal syntheses in special fields by men who have achieved distinction in them. Each of the fifteen sections of the association has a chairman for one year who

is also vice-president of the association. Upon retiring from office each vice-president delivers an address upon some subject in the field of his section. The retiring presidents of the affiliated societies also usually deliver formal addresses before their respective societies or before joint sessions of their societies and of societies in related fields.

As might be expected, the addresses of the vice-presidents of the association and of the presidents of affiliated societies are generally synthetic in character.

DR. CHAUNCEY D. LEAKE
PROFESSOR OF PHARMACOLOGY, UNIVERSITY OF CALIFORNIA MEDICAL SCHOOL; CHAIRMAN, SECTION ON HISTORICAL AND PHILOLOGICAL SCIENCES.

Syntheses are not simply enumerations of facts and theories in some field. They are coherent organizations of data and theories in special fields. They develop the inter-relations among the data and theories and often their relations to other fields of science and, in these days, to the complex problems of human relations.

Photographs of the retiring vice-presidents of the association are reproduced

R. L. SACKETT
EMERITUS DEAN OF ENGINEERING, PENNSYLVANIA STATE COLLEGE; CHAIRMAN OF THE SECTION ON ENGINEERING.

DR. PAUL R. CANNON
PROFESSOR OF PATHOLOGY, UNIVERSITY OF CHICAGO; CHAIRMAN OF THE SECTION ON MEDICAL SCIENCES.

DR. W. H. CHANDLER
PROFESSOR OF POMOLOGY, AND ASSISTANT DEAN, UNIVERSITY OF CALIFORNIA; CHAIRMAN OF THE SECTION ON AGRICULTURE.

DR. E. J. ASHBAUGH
DEAN OF THE SCHOOL OF EDUCATION, MIAMI UNIVERSITY; CHAIRMAN OF THE SECTION ON EDUCATION.

in this issue. They were nominated by their sections as being among the leaders of American science in their respective fields, and they were elected by the council of the association. The titles of their addresses are given in the General Program of the meeting. Representing, as they do, every principal field of the natural and social sciences, their addresses are a cross section of science at the present time.

Every day we read in the daily press that the present is a critical time in the world's history and every evening we hear, if we listen, the same sentiments expressed over the radio. Perhaps it is a critical period in which we live. But on the whole scientists contemplate it without hysteria. For every unfavorable influence that can be mentioned, they can name two new ones that are favorable. The statement can be illustrated by the destruction of human life. The war is taking a considerable number of lives directly and probably a greater number by malnutrition. But at its worst the destruction is not comparable to the plagues that once swept over the world. Even the reduction in infant mortality during the past forty years more than offsets any prospective loss of life in the present war, and the general improvement in diet will more than cure the consequences of temporary undernourishment. The proof of these statements lies in the rapid general increase of populations throughout the western world and in the striking improvement in human statures, at least in America.

The vice-presidents of the association are excellent representatives of scientists who regard mankind and its present troubles with the perspective of a knowledge of the long history of the earth and of the life that has evolved on its surface. They are aware of the great tragedies the world has witnessed, and of its marvelous triumphs as well. From this vantage point of knowledge they look with steady eye at the evils of a day.

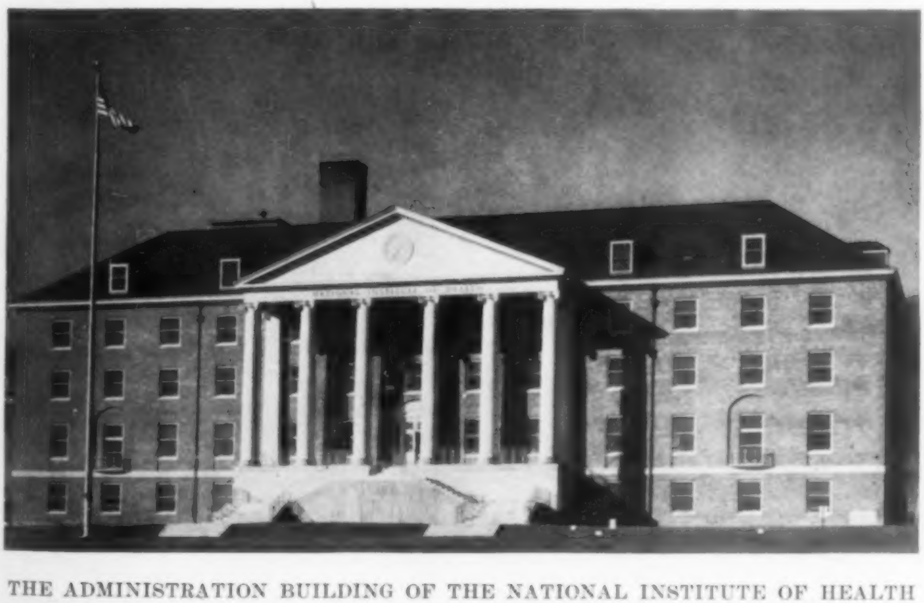
F. R. MOULTON,
Permanent Secretary

CONTRIBUTIONS TO PUBLIC HEALTH OF THE FEDERAL GOVERNMENT

The National Institute of Health in reality is the research division of the United States Public Health Service. On a bronze plaque in the rotunda of the Administration Building of the new institute at Bethesda, Maryland, there are inscribed these words: "This Institute is dedicated to the investigation of matters pertaining to the public health." That brief statement expresses very well the field of activity of the institute.

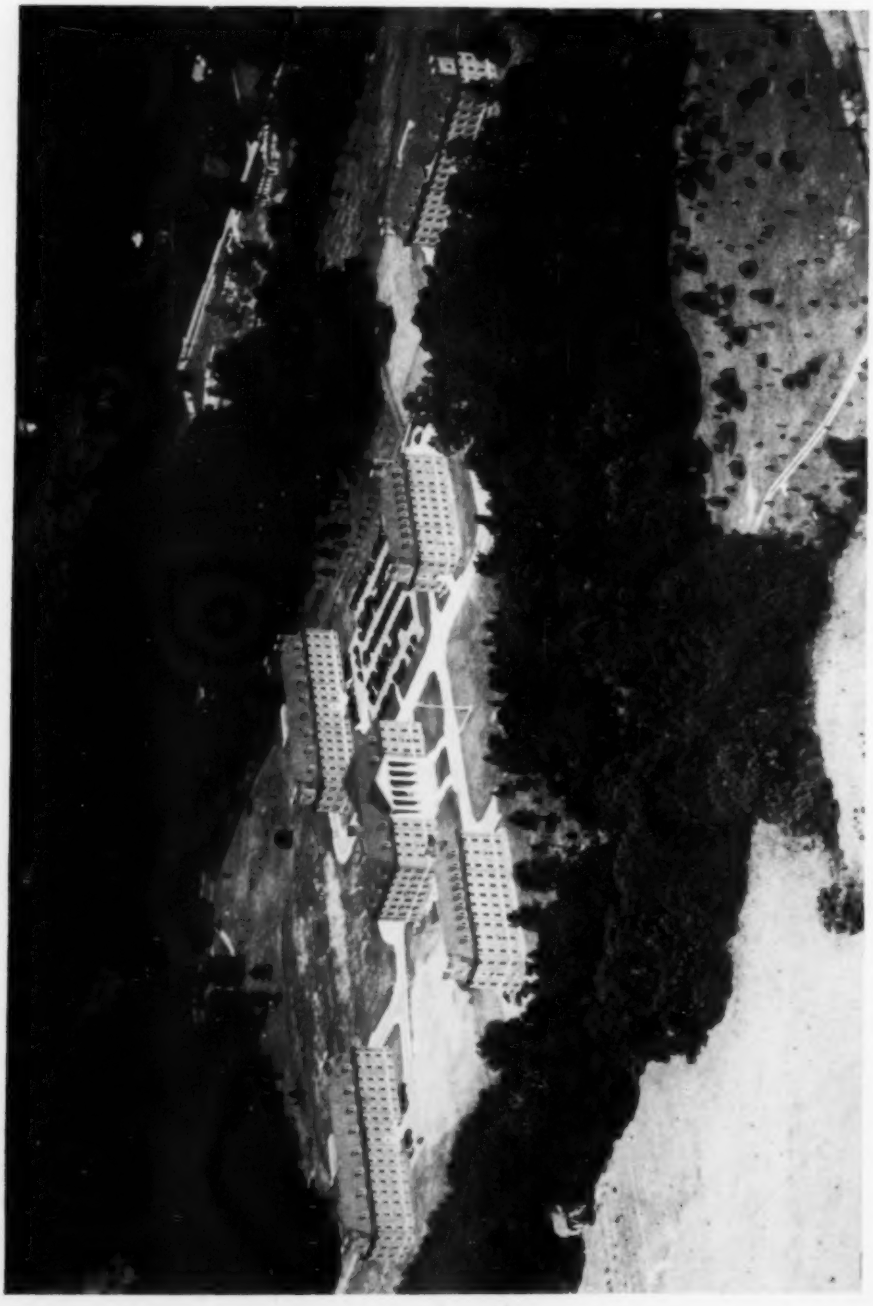
The institute came into being in a room at the old Marine Hospital at Stapleton, Staten Island, New York, in 1887. Its creation for study of infectious diseases was an example of the wisdom of those officers of the Public Health Service who foresaw that the development of public health work in the United States must be allied with research into these fields. A few years later the institute was transferred to Washington, D. C., and in 1901, with a very modest appropriation of $35,000, the Hygienic Laboratory, as it was then called, came into being on a small plot of ground transferred from the Navy Department. Additional buildings were added in 1918, and again in 1930, at which time the name of the laboratory was changed to the National Institute of Health. In 1935 Mr. and Mrs. Luke I. Wilson donated a tract of land of 45 acres at Bethesda, Maryland, to be used as a site for the National Institute of Health. Then followed in rapid succession the construction of the buildings to house the field and administrative offices of the institute, the Divisions of Industrial Hygiene and Public Health Methods, the National Cancer Institute, and finally the last two buildings of this group of six to house the Divisions of Infectious Diseases, Biologic Control, Zoology, Chemotherapy and Pathology, which were dedicated by the President of the United States on October 31, 1940. As the original site was too small, Mrs. Wilson and her son, after the death of her husband, donated an additional 40 acres.

Although there was never any doubt



THE ADMINISTRATION BUILDING OF THE NATIONAL INSTITUTE OF HEALTH

COMPLETED LAST FALL, THIS BUILDING HOUSES THE LIBRARY AND AUDITORIUM AS WELL AS THE ADMINISTRATION OFFICES.



AERIAL VIEW OF THE BUILDINGS OF THE NATIONAL INSTITUTE OF HEALTH AT BETHESDA, MARYLAND

THE BUILDING WITH THE PORTICO IS THE ADMINISTRATION BUILDING. THE TWO BUILDINGS IN FRONT OF IT HOUSE THE DIVISIONS OF INDUSTRIAL HYGIENE AND PUBLIC HEALTH METHODS. THE TWO BUILDINGS BEHIND IT WILL CONTAIN THE DIVISIONS OF INFECTIOUS DISEASES, BIOLOGIC CONTROL, ZOOLOGY, CHEMOTHERAPY AND PATHOLOGY. THE NATIONAL CANCER INSTITUTE CAN BE SEEN AT THE EXTREME RIGHT.

of the necessity and legal authority for the research work carried on at the institute, it was not until 1912 that Congress enacted into law the broad authority for public health research under which the work of the institute is still carried on. This act, which changed the name of the Public Health and Marine Hospital Service to the Public Health Service, also carried with it authority "to study and investigate the diseases of man and conditions influencing the propagation and spread thereof." Since an appropriation for "Field Investigations" was obtained under the authority of this act, we may take it as the first recognition by the Federal Government of its obligation for the conduct of public health research. Three other acts have had an important bearing on the scope and character of the research work of the institute; these are: the Biologics Act of 1902, which imposed upon the service the control of all biological and analogous products sold in the United States; the National Institute of Health Act of 1930, authorizing the institute to accept gifts for study, research and investigation into the fundamental problems of the diseases of man and matters pertaining thereto; and the National Cancer Institute Act of 1938.

Originally the institute consisted of four divisions—bacteriology and pathology, zoology, pharmacology and chemistry, and was a part of the Scientific Research Division of the Public Health Service. There existed at this time, in addition to the institute, over 20 field offices having to do with certain field investigations such as malaria, stream pollution, child hygiene, statistics, industrial hygiene, nutrition, and others. In 1937 Surgeon General Parran consolidated the Research Division with the National Institute of Health and by the establishment of additional divisions of the institute brought together all the field investigations' offices under one directing head.

The National Institute of Health therefore consists of nine divisions, which are as follows: Industrial Hygiene, Public Health Methods, Zoology, Pathology, Infectious Diseases, Biologics Control, Chemistry, Chemotherapy, and the National Cancer Institute.

The scope of public health investigations undertaken at the institute, while indicated in general by the names of the divisions, reaches down into broad ramifications of health and sanitation problems affecting the people of this country. Some few of these problems may be briefly sketched.

Year by year the population of this country is piling up more people in the older age groups. This means that more of our population are coming into the cancer age and this disease is now second in the important causes of death. The National Cancer Institute is attacking this problem from every angle; it is coordinating and stimulating cancer research in its own laboratories, as well as in other laboratories throughout the nation that are engaged in similar work; it is aiding in the development of cancer control programs in State and local communities; it is cooperating with other agencies in bringing to the people the simple understandable facts about the treatment of cancer; it is training scores of physicians in cancer treatment that these men may be more useful to the people of their communities; it has loaned radium to many hospitals throughout the nation where it is used without cost to those needing treatment, but unable to pay for it; and lastly it has made many grants-in-aid of money to universities and laboratories which need financial assistance in their research problems.

Many health problems have been and are being solved in the Division of Infectious Diseases: Goldberger's work on pellagra; Francis' discovery of tularemia; Spencer's Rocky Mountain spotted fever vaccine; Armstrong's work on poliomyelitis and the other virus diseases, and the contributions of

Dyer and his associates in the rickettsial diseases have given us insight into the prevention and control of many diseases.

In the Division of Industrial Hygiene, not only has this division added much to our knowledge of the prevention of silicosis in the dusty trades, but in a practical way it has aided in the establishment of over 25 industrial hygiene units in the separate states, which in the present expansion of industry in the defense program makes it possible in this country for the first time to control industrial hazards before they exist.

The stream pollution studies of the Division of Public Health Methods have been carried on uninterrupted since 1913. Besides the many contributions to our knowledge of the basic principles of stream purification made by Frost and his associates, the publications of this laboratory have been accepted by our courts of law in the regulation of stream flow in certain sanitary district areas.

From these few illustrations it will be seen that the work of the National Institute of Health in attacking the public health problems of the nation is roughly along two lines: through field and laboratory research we are reaching more deeply into the basic causes of disease and of health, and with this knowledge in our hands we are attempting to apply it to the practical welfare of the people.

LEWIS R. THOMPSON,
Director, National Institute of Health

THE WASHINGTON EXHIBIT OF THE BUREAU OF PLANT INDUSTRY

A DISPLAY covering some of the highlights of the work of the Bureau of Plant Industry was held in the patio of the Administration Building of the Department of Agriculture throughout the month of November. As it was impossible to cover the work of the entire bureau in the space available, attention was focused on investigations concerned with soils and plant nutrition, plant introduction, plant breeding and plant research of special interest to urban residents.

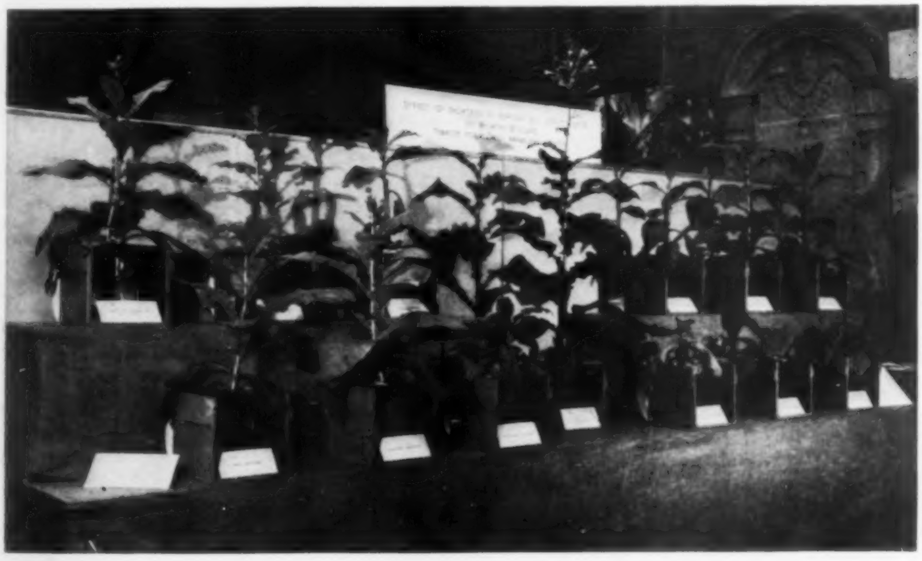
Living plants were used almost exclusively in the exhibits on plant nutrition, introduction, and breeding. This feature attracted unusual interest and lent an air of reality so often lacking in displays that rely on charts and photographs. Each individual exhibit and each of the four groups was planned to tell a story of research achievement. The presence of living plants made it possible to reduce to a minimum the need for explanatory placards. For students and others interested in more detailed discussion, brief mimeographed notes were available.

In planning the exhibit the interests of city dwellers were kept in mind. For this reason one of the features was an exhibit on lawns. At the entrance of the patio a beautiful bluegrass lawn 6 feet square showed results of fall seeding and proper fertilizing. Nearby were four smaller squares of sod each of which had been the victim of poor management. Hundreds of visitors viewed this exhibit and compared notes on their difficulties with lawns.

In the first half of the month chrysanthemums introduced by the bureau were displayed around the fountain in the center of the patio. For the last two weeks this place of honor was occupied by Easter lilies in bloom, forced from American-grown bulbs. In each instance the flowers represented plant breeding work of the bureau.

The soils exhibit was built around an enlarged copy of the soil map of the United States. Five-foot monoliths of eight representative soil groups of the country gave many visitors their first opportunity to see what lies beneath the top layer of soil. Equipment used by

CLAUDE R. WICKARD, SECRETARY OF AGRICULTURE, AND DR. M. A. McCALL, ASSISTANT CHIEF OF THE BUREAU OF PLANT INDUSTRY, EXAMINING THE TOMATO SECTION OF THE EXHIBIT OF THE BUREAU OF PLANT INDUSTRY.



PLANT NUTRITION EXHIBIT

THE TOBACCO PLANT IN THE CENTER WAS GIVEN ALL SOIL CONSTITUENTS NECESSARY FOR ITS FULL DEVELOPMENT. EACH OF THE STUNTED PLANTS ON EITHER SIDE DID NOT RECEIVE ONE OF THE REQUIRED MINERALS.

GENERAL VIEW OF THE EXHIBIT OF THE BUREAU OF PLANT INDUSTRY

IN THE LEFT FOREGROUND IS THE EXHIBIT OF POTATOES, NUTS AND GRASSES; IN THE CENTER FOREGROUND IS EQUIPMENT USED IN MAKING MACARONI, EMPLOYED BY THE BUREAU IN TESTING THE VALUE OF VARIOUS WHEATS AS MACARONI INGREDIENTS. ALONG THE FURTHER WALLS ARE THE EXHIBITS OF PLANT INTRODUCTION AND OF SOIL AND PLANT NUTRITION.

soil surveyors was on display and a series of photographs told how this work is performed.

An exhibit that attracted much attention was a series of 11 tobacco plants growing in glass jars containing nutrient solutions. The center plant had received all the elements necessary for normal development, and stood about five feet tall. On either side were five other plants of the same age. Each had been deprived of one of the elements necessary for normal growth. On a nearby table was an exhibit of fertilizer materials commonly used to provide these elements.

To further emphasize the relationship between soils and plants an exhibit on soil microorganisms was used. The feature of this part of the exhibit was a group of microscopes on which were mounted living nematodes. Slides were replaced every few days so that visitors could see the nematodes moving about under a low power lens.

Although nearly every fruit, vegetable, cereal and nut may seem good American crops, many of them like our people have come from other lands. Two world maps, by a series of symbols, showed that nearly every country of the globe has made some contribution to our foodstuffs or our flower gardens.

NEW VARIETIES OF CHRYSANTHEMUMS
ORIGINATED AS PART OF THE WORK OF THE BUREAU OF PLANT INDUSTRY.

Various tropical and subtropical exhibits included coconuts, once from Malaya, now from Florida; persimmons, once from China, now from California, Texas and other states; pistachio nuts, once from Asia Minor, now from the Pacific Coast, and so the list might be continued almost indefinitely.

As one walked through this portion of the show, looking at the murals of bamboo, rice, persimmons, dates, wild tomatoes, rubber, navel oranges, coconuts; noting the various palms from

Central and South America, the cacti from Argentina, haws from China, almonds from Spain; and studying the seed collections, one could only marvel at the diversity and value of the crops which have been "naturalized" here as a result of plant introduction efforts both public and private.

Except for tree fruits and nuts, all the plant-breeding exhibits consisted of living plants. Crops represented were apples, alfalfa, clovers, grass, cotton, corn, oats, sorghum, wheat, tobacco, tomatoes, sugarcane, sugarbeets and nuts. In most instances the plants were grown in greenhouses especially for the exhibit. Several stalks of cotton with open bolls were sent up from Mississippi and a group of dry-land grasses including Buffalo grass was sent from the Southern Great Plains station at Woodward, Oklahoma.

The aim was to show results, rather than techniques of plant breeding. This was portrayed in a striking manner in the tomato exhibit. This exhibit illustrated how plant diseases are often controlled by breeding. In this case the objective was resistance to wilt. The exhibit consisted of 6 mature plants, all of which had red, ripe fruit, and 12 seedlings, about the right age for transplanting. First in the line-up of mature plants was the wild Peruvian currant, resistant to wilt and collected in Peru by a plant explorer several years ago. Its fruit was about the size of a marble. Next was a typical plant of the Marglobe, introduced by the bureau several years ago and now the leading commercial variety in the country. The third plant was a first generation cross of the first two. The remaining plants were successive backcrosses to the Marglobe parent, and each showed a marked increase in size of fruit. The final product had fruit as large and attractive as that of the Marglobe, and resistant to wilt.

The young plants demonstrated the effect of wilt on Bonny Best, a popular commercial variety, Marglobe, Peruvian currant and the new hybrid. Bonny Best plants were completely killed and Marglobe was badly stunted. The currant and its offspring showed no effects from inoculation with the fungus.

Photographs enlarged to 60 by 80 inches served the double purpose of "walling in" the patio and providing an attractive background for the individual exhibits. In so far as it was possible to get suitable negatives, the photographs were on the same subjects as the exhibits directly in front.

Special invitations were sent to science classes of all nearby high schools and colleges. No actual count of visitors was attempted, but from the number who registered it seems safe to say that at least 3,000 students alone visited the exhibit, in addition to many thousand others. Most of the students came with their teachers and took notes on what they saw.

The exhibit was arranged by a special committee, consisting of one member from each division of the bureau.

E. C. AUCHTER,
Chief, Bureau of Plant Industry
U. S. Department of Agriculture